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No. 04-717

IN THE

Supreme Court of the United States

AMERICAN AXLE & MANUFACTURING, INCORPORATED,

Petitioner,

v.

DANA CORPORATION,

Respondent.

On Petition for Writ of Certiorari to the United States Court of Appeals for the Federal Circuit

PETITION FOR WRIT OF CERTIORARI

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QUESTION PRESENTED

The question presented is as follows:

1. Does the clearly erroneous review standard of Rule 52 of the Federal Rules of Civil Procedure apply to the review, by the Court of Appeals for the Federal Circuit, of findings of fact made by a district court in determining the meaning of disputed terms in the claims of a patent, or, as that appellate court has held, based upon an undeniable misreading of this Court's opinion in *Markman v. Westview Instruments, Inc.*, 517 U.S. 370 (1996), is the court free to entirely disregard the district court's findings of fact, and to make and substitute its own findings of fact on a *de novo* basis?

RULE 29.6 CORPORATE DISCLOSURE STATEMENT

The parent company of petitioner American Axle & Manufacturing, Inc., is American Axle & Manufacturing Holdings, Inc. Barclays Global Investors, N.A., a wholly owned subsidiary of a publicly-held company, Barclays Global, PLC, owns 10% or more of the petitioner's stock.

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PETITION FOR A WRIT OF CERTIORARI

OPINIONS BELOW

The opinion of the court of appeals (App., *infra*, 1a-14a) was designated as "not for publication" but is reported on the Lexis database. The opinion of the district court (App., *infra*, 15a-21a) was vacated and remanded.

JURISDICTION

The court of appeals' decision was entered on August 27, 2004. The jurisdiction of this Court is invoked under 28 U.S.C. § 1254(1).

CONSTITUTIONAL AND STATUTORY PROVISIONS INVOLVED

Rule 52 of the Federal Rules of Civil Procedure provides, in relevant part: "Findings of fact, whether based on oral or documentary evidence, shall not be set aside unless clearly erroneous, and due regard shall be given to the opportunity of the trial court to judge of the credibility of the witnesses."

STATEMENT OF THE CASE

Petitioner-Appellant American Axle & Manufacturing, Inc. ("American Axle") petitions this Court to review a decision of the Court of Appeals for the Federal Circuit ("Federal Circuit"). *See Dana Corp. v. Am. Axle & Mfg., Inc.*, 2004 U.S. App. LEXIS 18265 (Fed. Cir. Aug. 27, 2004). App., *infra*, 1a-14a. That court rejected the district court's construction of certain terms in the claims of two patents owned by Respondent-Appellee Dana Corporation ("Dana"), and substituted its own construction of those terms. App., *infra* at 13a. The district court's award of summary judgment in favor of American Axle was overturned and the case was remanded for further proceedings. App., *infra* at 14a.

I. Historical Background to the Controversy

This petition raises questions of fundamental significance to the proper administration of the patent laws. These questions center on the legality of the Federal Circuit's displacement of the district courts from their congressionally assigned role as the forum where the meaning of patent claims is factually determined.

In *Markman v. Westview Instruments, Inc.*, 517 U.S. 370 (1996), this Court reviewed a decision by a sharply divided Federal Circuit as to the applicability of the Seventh Amendment to disputes about the construction of patent claims. *See Markman v. Westview Instruments, Inc.*, 52 F.3d 967 (Fed. Cir. 1995) (en banc), *aff'd*, 517 U.S. 370 (1996). This Court held that the issue of claim construction was not subject to the Seventh Amendment and was triable to a judge. *See Markman*, 517 U.S. at 372.

The Seventh Amendment issue was the sole issue before this Court for review in *Markman*.[1] In the Federal Circuit's *en banc Markman* decision, however, a majority of Federal Circuit judges also ruled that fact-based district court claim construction decisions should be subject to *de novo* review (hereinafter the "*de novo* standard"). *See* 52 F.3d at 984 n.13.

Although the Federal Circuit has exclusive jurisdiction to hear appeals from district court decisions in patent cases, *see* 28 U.S.C. § 1295(a), it has no special education in the engineering or scientific arts. Nonetheless, in its *en banc Markman* decision, the Federal Circuit held that the court would no longer review district court claim construction decisions, which are based on a factual record that often includes substantial expert testimony, under the

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[1] *See Markman v. Westview Instruments, Inc.*, 52 F.3d 967 (Fed. Cir. 1995), *petition for cert. filed*, No. 95-26, 1995 WL 17063340 (July 3, 1995), *cert. granted*, 515 U.S. 1192 (Sept. 27, 1995) (No. 95-26).

clearly erroneous standard of Rule 52 of the Federal Rules of Civil Procedure. The Federal Circuit majority held that, because claim construction was an issue of law, the meaning of a patent claim could *never* raise factual questions. The claim's meaning was to be *divined by judges, relying exclusively on the "intrinsic evidence"*—the patent and the Patent Office file pertaining to the patent (including prior art references cited in those materials). The majority also held that extrinsic evidence (such as testimony by industry or academic experts) should not be used to interpret a claim. *See Markman*, 52 F.3d at 986.

This decision of the Federal Circuit majority ran counter to decades of case law. These cases uniformly recognized that when the terms of a patent claim are disputed, resolution of the dispute will frequently involve factual issues. The cases held without exception that a district court's resolution of those factual issues is subject to Rule 52's clearly erroneous standard. *See, e.g., Minnesota Mining & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 1565 (Fed. Cir. 1992); *Uniroyal, Inc. v. Rudkin-Wiley Corp.*, 837 F.2d 1044, 1054 (Fed. Cir. 1988); *H.H. Robertson Co. v. United Steel Deck, Inc.*, 820 F.2d 384, 388-89 (Fed. Cir. 1987); *Perini Am. v. Paper Converting Mach. Co.*, 832 F.2d 581, 584 (Fed. Cir. 1987).

This Court's *Markman* decision reflects this case law. The Court made clear that the resolution of claim construction disputes would often involve factual issues and extrinsic evidence.[2] *See Markman*, 517 U.S. at 385-88. In

[2] The Court at one point referred to the issue as "fall[ing] somewhere between a pristine legal standard and a simple historical fact." *Markman*, 517 U.S. at 388 (quoting *Miller v. Fenton*, 474 U.S. 104, 114 (1985)). Elsewhere, it referred to "mongrel practice[s] (like construing a term of art following receipt of evidence)." *Id.* at 378. The court also recognized that claim construction had "evidentiary underpinnings." *Id.* at 390.

fact, at the very outset of its opinion, the Court stated that the issue to be decided was "[whether] a jury will determine the meaning of any disputed term of art about which *expert testimony is offered*." *Id.* at 372 (emphasis added).

Following this Court's *Markman* decision, various panels of the Federal Circuit reasonably interpreted it to implicitly *reject* the *de novo* standard adopted by the Federal Circuit majority in its *en banc Markman* decision. Accordingly, they returned to the traditional application of Rule 52. *See, e.g., Eastman Kodak Co. v. Goodyear Tire & Rubber Co.*, 114 F.3d 1547, 1555-56 (Fed. Cir. 1997); *Fromson v. Anitec Printing Plates, Inc.*, 132 F.3d 1437, 1446 (Fed. Cir. 1997); *Metaullics Sys. Co., L.P. v. Cooper*, 100 F.3d 938, 939 (Fed. Cir. 1996); *Wiener v. NEC Elecs., Inc.*, 102 F.3d 534, 539 (Fed. Cir. 1996).

To resolve this split within the court, the Federal Circuit took up the issue again, *sua sponte*, in its *en banc* decision in *Cybor Corp. v. FAS Techs., Inc.*, 138 F.3d 1448 (Fed. Cir. 1998) (en banc). The court majority (there were six separate opinions) again firmly maintained, as it had in its *en banc Markman* decision, that if claim construction is an issue of law, then the adoption of a *de novo* standard and the attendant prohibitions against district court fact-finding through the use of extrinsic evidence were *required*. *See id.* at 1456. The Federal Circuit majority inexplicably mischaracterized this Court's decision in *Markman*, insisting that this Court's opinion supported its ruling as to the *de novo* standard. *See id.* at 1455-56.

In both the Federal Circuit's *Markman* and *Cybor* decisions, the dissenters argued that the court was opening a Pandora's box that would unleash a nightmare of intractable problems—problems that would threaten the patent system's very viability as a meaningful incentive to innovation. Time has proven them right.

As discussed below, *infra* pp. 22-23, application of the *de novo* standard to claim construction decisions has resulted in an unprecedented and unconscionable reversal rate of 30-50 percent in patent cases. *That is nearly five times higher than the reversal rate in other circuit courts of appeals. See infra* p. 23. This reversal rate has engendered enormous uncertainty about outcomes in patent litigations, and in turn, has had a chilling effect on settlements in patent cases. *See infra* pp. 24-26. Further, the *de novo* standard is largely responsible for the enormous discrepancy between the number of pending patent cases as compared to pending non-patent cases. *See infra* pp. 25-26. All of the above, of course, has massively increased the cost of patent litigation. Moreover, the *de novo* standard is undermining the credibility and perceived legitimacy of the Federal Circuit as a competent federal court of appeals. *See infra* pp. 28-30.

This Court should act now. Given the Federal Circuit's exclusive jurisdiction over patent appeals, there is no possibility of a "split among the circuits." A Federal Circuit majority, ascribing to this Court's *Markman* opinion rulings and endorsements that it surely did not contain, on an issue that this Court surely did not consider, has issued two *en banc* opinions enunciating and reaffirming its commitment to the *de novo* standard and its related prohibition against the use of extrinsic evidence to interpret a patent claim.

In her dissent in *Markman*, Judge Newman warned: "This holding . . . creates a litigation system that is unique to patent cases, unworkable, and ultimately unjust." 52 F.3d at 999 (Newman, J., dissenting). The "unique" nature of the litigation system the Federal Circuit majority created lies in the fact that lay appellate judges have arrogated to themselves the authority to decide complex technological fact issues on their own, giving "no deference" to the factual findings issued by the district court after eviden-

tiary submissions by experts and live hearings. As Judge Newman further stated: "The [Federal Circuit's decision in *Markman*] denies the critical values of the trial, and moves the Federal Circuit firmly out of the juridical mainstream." *Id.* at 1026.

Despite the strong and continuing dissents by Judge Newman and others, the Federal Circuit majority has refused to reconsider the issue. All that the majority has seen fit to do is tinker at the outer edges of its ruling—*e.g.*, whether dictionaries should be viewed as intrinsic or extrinsic evidence.[3] In dissenting from the majority's decision to review the dictionary issue *en banc*, Chief Judge Mayer stressed the intellectual dishonesty of the *de novo* standard, a point other jurists have also made:

> Until the Federal Circuit is willing to reconsider its holdings in [*Markman*] and [*Cybor*] that claim construction is a pure question of law subject to *de novo* review in this court, any attempt to refine the process is futile. Nearly a decade of confusion has resulted from the fiction that claim construction is a matter of law, when it is obvious that it depends on underlying factual determinations which, like all factual questions if disputed, are the province of the trial court, reviewable on appeal for clear error. To pretend otherwise inspires cynicism. Therefore, and because I am convinced that shuffling our current precedent merely continues a charade, I dissent from the *en banc* order.[4]

In short, a crisis exists that has festered for too long and that only this Court can resolve.[5]

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[3] *See Phillips v. AWH Corp.*, 376 F.3d 1382 (Fed. Cir. 2004) (per curiam).

[4] *Id.* at 1384 (Mayer, C.J., dissenting).

[5] *See generally*, Tarek N. Fahmi & Elena B. Dreszer, *Case Note:* De Novo *Review of Claims Construction or A Wasted Effort of the District*

II. Proceedings In This Case

In this case, two related patent applications were submitted to the Patent Office. The applications related to driveshafts, which are hollow tubes used to connect a vehicle's transmission to its rear axle.

Both applications related to the use of a tube with a larger central diameter and smaller diameter ends. This would add strength to the tube, and allow the driveshaft to support higher speeds. Both patent applications called for the diameters of the two ends of the tube to be reduced. One patent specifically mentioned a well-known method called "swaging", and Dana argued that this method would be used with respect to the claims of both patents. Reducing the diameter of the tube ends by swaging or some other method, was necessary so that they could be efficiently attached to the axle and transmission assemblies; the unswaged bulk of the tube's length would be unaffected—it would retain the larger diameter and its advantages. App., *infra*, 26a-60a.

The claims as originally filed were rejected by the Examiner as failing to meet the requirement of novelty—that is, the Examiner found that both alleged inventions were anticipated[6] and/or obvious[7] in view of the prior art.

Court: Interactive Gift Express, Inc. v. Compuserve, Inc., 19 SANTA CLARA COMPUTER & HIGH TECH. L.J. 315 (2002); Arti K. Rai, *Patent System Reform: Specialized Trial Courts: Concentrating Expertise on Fact*, 17 BERKELEY TECH. L.J. 877 (2002); William C. Rooklidge & Matthew F. Weil, *Essay: Judicial Hyperactivity: The Federal Circuit's Discomfort With Its Appellate Role*, 15 BERKELEY TECH. L.J. 725 (2000); M. Reed Staheli, *Comment: Deserved Deference: Reconsidering the* De Novo *Standard of Review for Claim Construction*, 99 MARQ. INTELL. PROP. L. REV. 181 (1999).

[6] *See* 35 U.S.C. § 102(b). Anticipation means that every element of a patent claim may be found in a single prior art reference published more than one year prior to the filing of the application for patent.

(Footnote 7 appears on the following page.)

The Examiner believed that the applications were not novel in part because of an earlier patent granted to one Swenson, which disclosed a driveshaft tube whose tube ends had been swaged to reduce their diameters. Looking for a means to overcome Swenson, Dana seized upon the fact that the Swenson patent was silent as to the issue of wall thickness. It was well known in the art that swaging a section of a metal tube would cause that section's wall thickness to increase. To distinguish its claimed inventions over Swenson, Dana amended its claims to add the words "substantially uniform wall thickness," a characteristic that was absent from Swenson's tubes.

The Examiner agreed with Dana. The Examiner ruled that making a driveshaft tube having swaged ends and a uniform wall thickness from end to end was a sufficient advance in the art to warrant the allowance of Dana's patent applications.

The district court held a special claim construction hearing for purposes of interpreting the disputed claim term "substantially uniform wall thickness." The court was given a substantial volume of extrinsic evidence, including affidavits and deposition testimony.[8] One affidavit was by

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[7] *See* 35 U.S.C. § 103. Obviousness means that the prior art, when viewed by a person of ordinary skill in the art at the time the application was filed, would have considered the claimed invention to be obvious.

[8] In adopting the *de novo* standard, the Federal Circuit realized it would have to allow the district courts at least some access to extrinsic evidence so that they could understand the case and the technology at issue. In doing so, however, the Federal Circuit majority was forced to adopt the fiction that a district court judge, having had access to expert testimony, scientific demonstrations and the like, could then construe the patent terms solely by reference to the intrinsic evidence, putting aside everything that the court had learned from the extrinsic materials. *See, e.g., Markman*, 52 F.3d at 983; *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1583-85 (Fed. Cir. 1996). It is this fiction that has drawn some

Mr. Ploughe, a twenty-year veteran of the industry and an Alcoa engineer. Alcoa fabricated the actual driveshafts specified and purchased by both Dana and American Axle. He had an intimate knowledge of the effects of swaging on driveshafts. He testified to a wide variety of facts supporting American Axle's position. The other affidavit was submitted by the inventor, Mr. Breese, a Dana employee with ten years of experience. Both affiants had been deposed. The patent attorney who handled the prosecution of the patents was also deposed. Various other documents, including data on the impact of swaging on driveshafts, were also submitted.[9]

The claim construction dispute boiled down to three issues:

First, it was known that the wall thickness of any tube would vary very slightly simply as a result of the so-called manufacturing tolerances.[10] American Axle's position was

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of the harshest attacks on the *de novo* standard, with Federal Circuit as well as district court judges labeling the fiction "sophistry", and a "charade". *See infra* pp. 28-30. In this case, for example, both parties argued to the district court judge that he should only consider the intrinsic evidence, as prescribed by *Cybor*. Yet both parties submitted substantial extrinsic evidence since, in its absence, they could not argue, and the court could not be expected to understand, their positions as to any issue in the case, including what were clearly factual issues. The district court made no effort to engage in the fiction of "forgetting" all the extrinsic evidence he saw so that he could focus solely on the intrinsic evidence. He based his decision on the evidence before him, intrinsic and extrinsic. As noted below, *infra* pp. 12-14, the court of appeals, on its review of this case, did the same thing; it relied upon all of the evidence of record, intrinsic and extrinsic.

[9] While Mssrs. Ploughe and Breese were not mentioned by name in the district court's opinion, their testimony was referenced at the hearing and it may be inferred that the district court gave due consideration to their affidavits and the other extrinsic evidence in the record.

[10] Manufactured materials will always vary by some +/- amount relative to a benchmark.

that the words "substantially uniform" were an acknowledgement that the wall thickness could not be perfectly uniform because of these manufacturing tolerances. But apart from that deviation from perfect uniformity, American Axle's position was that the words "substantially uniform wall thickness" meant a tube whose swaged ends had the same wall thickness as the non-swaged middle section of the tube, such that the entire tube had the same wall thickness from end to end.

Dana's argument, on the other hand, was that the words "substantially uniform" were intended to allow for variations in wall thickness due to swaging, in addition to the variations due to the manufacturing tolerances.

Second, in a Petition to Make Special—a petition to expedite the Patent Office's review of the application—Dana discussed a metal baseball bat patent (the "Wilson patent").[11] This Petition is the only place in the prosecution history in which Dana discusses the phrase "substantially uniform wall thickness." As noted, uncontrolled swaging causes an increase in wall thickness. The Wilson patent taught the use of swaging in making metal baseball bats that had a "substantially uniform wall thickness" after swaging. Dana stated that the Wilson patent was able to claim this "substantially uniform wall thickness" because a "mandrel" was used to control the wall-thickening effects of swaging. (A mandrel is a metal rod or bar around which material, such as metal or glass, may be shaped.)

American Axle argued that statements Dana chose to make to the Patent Office in the context of the Wilson patent effectively admitted that one could *not* obtain a substantially uniform wall thickness if one did *not* control for

[11] Dana argued, and the Examiner agreed, that this patent was not prior art against Dana's applications, because the Wilson patent related to a different sphere of commercial activity (*i.e.*, sports, not the automotive arts).

the effects of swaging. Accordingly, Dana could not claim that the phrase "substantially uniform wall thickness" covered increases in wall thickness due to where, the swagging—as in Dana's patents—was carried out in an uncontrolled fashion.

The third issue related to the fact that, while Dana had amended its claims to refer to the issue of wall thickness, it had not amended the applications' specifications. The specification is the section of a patent that discusses the invention in detail, with diagrams, so that a person of ordinary skill in the art can practice the invention. *See* 35 U.S.C. § 112. Although there was nothing in the text of the specifications that discussed wall thickness, the drawings in the patents showed the post-swaged tube with exactly the same wall thickness for the tube ends (which had been swaged) as for the body of the tube (which had not). *See* App., *infra* at 28a-30a, 47a-48a.

After reviewing the parties' submissions and conducting the hearing, the district court ruled in American Axle's favor on all three issues. Resolving each issue required determinations of credibility, the weighing of conflicting testimony and evidence, and a determination of how a person of ordinary skill in the art would have understood the claims and prior art when the patent applications were filed.

Dana appealed. The Federal Circuit, taking full advantage of the right it had arrogated to itself under the *de novo* standard, dismissed the district court's findings without holding that any of them were clearly erroneous, arbitrary or unreasonable.

However, rather than treating the issues as pure questions of law, as to which no fact issues could exist, the Federal Circuit made its own factual findings based on the extrinsic evidence in the record, doing so without holding

that any of the district court's findings were clearly erroneous, arbitrary or unreasonable.

The basis for reversal was the court of appeals' "disagreement" with the factual findings of the district court. The Federal Circuit "disagreed" with the district court's adoption of Ploughe's testimony as to how one of ordinary skill in the art would have understood the words "substantially uniform." Rather, it accepted the views argued by Dana based on the Breese affidavit. It similarly "disagreed" with the district court's reliance on the fact that the diagrams in the patents showed parallel lines with a uniform wall thickness from end to end, including the portions that had been swaged. App., *infra* at 11a. Finally, it "disagreed" with the district court's analysis of what the Wilson patent taught and the admissions Dana made with reference to it.

The way the Federal Circuit's opinion reads, one might get the impression that the appeal was being decided by judges having expertise in mechanical engineering. That, of course, was not the case. No more than other federal judges, the judges of the Federal Circuit do not have the expertise to parse the patents and the prior art on their own. All the court of appeals did was to boot the district court out of the fact-finder's chair, and substitute its own views based on a cold paper record of extrinsic evidence.

At one point, the Federal Circuit indicated that it might have considered adopting a claim construction that contained actual numerical bounds that would establish when a wall thickness was "substantially uniform" and when it was not. App., *infra* at 13a. The court stated, however, that the record did not contain sufficient expert evidence for *it* to make the necessary factual findings. App., *infra* at 13a. These remarks are revealing. Here, we have the Federal Circuit, having purportedly banned the use of extrinsic evi-

dence for purposes of construing a claim, indicating that it would have liked the record to contain more.

Also ironic is the court's statement that the record was insufficient for *it* to make findings as to numerical ranges. How would the court know whether or not the record was sufficient to establish numerical ranges? Again, the judges of the court of appeals are laymen—they are, in the words of Judge Learned Hand, "altogether incompetent", *see infra* p. 20, to venture into areas of technology and make their own judgments on scientific or engineering issues. Here, the judges on the panel manifestly lacked the knowledge and expertise to determine if the scientific record was sufficient to support findings as to numerical ranges and, if the record were sufficient, to make findings of fact establishing those ranges.

The district court's claim construction was straightforward and more than amply supported by the intrinsic and extrinsic evidence viewed as a whole. The court stated that it "interprets the phrase 'substantially uniform wall thickness' as used in the patents as meaning 'a wall thickness that does not vary more than the wall variation in the tube wall *before swaging*.'" App., *infra* at 24a (emphasis added). This finding is virtually a restatement of what Dana told the Patent Office in regard to the Wilson patent. In other words, if a section of the tube were swaged, the finished tube could not reflect the increased wall thickness that would have resulted from such swaging if not controlled as in, for example, the Wilson patent. The entire tube, end to end, had to have a uniform wall thickness.

The Federal Circuit's claim construction, by contrast, was anything but clear and precise. It stated:

> [W]e hold that "substantially uniform wall thickness" is properly construed to mean that the wall of the tube is largely or approximately uniform in

> thickness, ***but*** may vary at least as much as the wall thickness varied prior to swaging plus the variation in wall thickness that necessarily results from swaging a portion of the tube in accordance with the claimed invention of the '093 and '042 patents.

App., *infra* at 13a (emphasis added).

Far from reflecting expertise, a thorough knowledge of the record, or careful attention to drafting, this fifty-five word claim construction was ill-considered and can only add more confusion and more uncertainty, not to mention additional litigation costs, as the district court and the litigants struggle to make sense out of the court of appeals' handiwork. For example, in what way are the words "approximately" and "largely" different from "substantially"? What is meant by "approximately ***or*** largely"? How do these words differ? *Why* did the Federal Circuit gratuitously inject this new ambiguity? These are not nit-picks. Issues of this nature are litigated all the time in patent cases, where the claim terms are thoroughly parsed.

In addition, Dana may assert on remand that the Federal Circuit's imprecise claim construction expanded the scope of the patent claims to cover any and all increases in wall thickness due to swaging, without regard to their substantiality. Note the first part of the Federal Circuit's sentence—"the wall of the tube is largely or approximately uniform in thickness." But this wording is immediately amended if not contradicted by the "***but***" clause that follows—"*but may vary at least as much as the wall thickness varied prior to swaging plus the variation in wall thickness that necessarily results from swaging the tube in accordance with the claimed invention of the '093 and '042 patents.*" App., *infra* at 13a. Does this mean that *all* increases in wall thickness due to swaging are covered by the claim? It is little wonder that the panel designated its

decision as non-precedential, and as an opinion that can never be cited to the court.[12]

This is what happens—and has happened in hundreds of Federal Circuit cases—because the Federal Circuit has dismissed the applicability of Rule 52 to claim construction issues and has usurped the powers rightly vested in the district courts to deal with those issues.

The decision below also brings to mind Chief Judge Mayer's warning that the effect of the majority's decision in *Markman* "is to make of the judicial process a charade, for notwithstanding any trial level activity, [the Federal Circuit] will do pretty much what it wants under its *de novo* retrial." 52 F.3d at 993 (Mayer, J., concurring).

REASONS FOR GRANTING THE PETITION

This petition should be granted because the Federal Circuit's adoption of the *de novo* standard for its review of

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[12] The Federal Circuit's practice of designating more than forty percent of its claim construction decisions as non-precedential and not citable to the court is further evidence that the Federal Circuit simply does not "get" this Court's message in *Markman*. *See* Christian A. Chu, *Empirical Analysis of the Federal Circuit's Claim Construction Trends*, 16 BERKELEY TECH. L.J. 1075, 1128 (2001). This Court emphasized in its *Markman* decision that an important consideration in giving the issue of claim construction to the judge rather than the jury was the uniformity that would be promoted by the application of *stare decisis* to patent claim construction. 517 U.S. at 390-91. By depriving hundreds of its claim construction decisions of any precedential value, the Federal Circuit renders meaningless this key rationale for this Court's decision. Indeed, it often has the opposite effect, sewing confusion rather than promoting uniformity. For example, in one case, two Federal Circuit panels reached opposite constructions of the *same patent claim* in two different lawsuits. *Compare CVI/Beta Ventures, Inc. v. Tura LP*, 112 F.3d 1146 (Fed. Cir. 1997) *with CVI/Beta Ventures, Inc. v. Custom Optical Frames, Inc.*, Nos. 96-1070, 95-1486 (Fed. Cir. June 19, 1996), *available at* 1996 WL 338388. Circuit Judge Michel sat on the majority in both panels.

district court claim construction decisions is inflicting and will continue to inflict irreparable harm on the patent system. Not only has the Federal Circuit acted *ultra vires* in adopting the *de novo* standard, this unlawful conduct has occasioned an unheard of reversal rate in patent suits, has disincentivized settlements, and has raised the cost of patent litigation to a point which undermines the patent system's purpose as a spur to innovation. It has also, as a number of distinguished judges have pointed out, introduced an element into patent litigation that is tending to undermine the credibility and legitimacy of a federal court of appeals, and of a patent system that has served this country well for over two hundred years.

I. The *De Novo* Standard Is *Ultra Vires* the Federal Circuit

The *de novo* standard is *ultra vires* the Federal Circuit because the resolution of disputes as to claim construction will frequently, if not invariably, involve the determination of factual issues subject to the clearly erroneous standard of Rule 52. The Federal Circuit's primary justification for the *de novo* standard—that claim construction is an issue of law and, therefore, cannot admit of findings of fact—is manifestly false.

Further, the Federal Circuit's *de novo* standard requires it to abandon the axiom that claims must be construed by a person of ordinary skill in the art—a hypothetical, historical figure fashioned by the district court from extrinsic evidence. The Federal Circuit's attempt to pay homage to this rule while flagrantly violating it is what has led various jurists to refer to the *de novo* standard as a "charade," as "sophistry and fiction," as engendering "cynicism," and as a standard that provides a "perverse incentive" to the district courts to hide their use of the extrinsic evidence they *must* use to perform the tasks this Court assigned to them in *Markman*.

A. The *De Novo* Standard Cannot Be Justified Simply Because Claim Construction Is, Whether in Whole or in Part, an Issue of Law

In its *Cybor* decision, the Federal Circuit claimed that this Court's decision in *Markman* implicitly ratified its adoption of the *de novo* standard. *See Cybor*, 138 F.3d at 1455. The Federal Circuit purported to excavate this endorsement from this Court's reference to claim construction, in the context of its Seventh Amendment analysis, as an issue of law. It is evident, however, that the Federal Circuit majority seriously misread this Court's opinion.[13]

This Court has always made clear that labeling an issue as "one of law" says little about what facts the court will need in order to resolve that issue. The notion that an issue of law, committed to a court for adjudication, cannot raise and require the determination of fact issues is dead wrong. The denotation of an issue as one "of law", or as a "legal issue", simply means that it falls within the province of a judge to decide. It does not mean the issue is fact-free. In a host of other contexts—such as motions to dismiss for *forum non conveniens*[14] and for lack of subject matter jurisdiction,[15] in reviewing the grant or denial of injunc-

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[13] As Chief Judge Mayer has remarked in discussing the majority's mischaracterization of this Court's opinion: "[I]t seems to me that the [Supreme] Court would not also have repealed part of the Federal Rules of Civil Procedure and Evidence without so much as a mention. . . . Nor would it have so excused this court from the normal, historical role of appellate courts to review for reversible error, and installed it as a collegial trial court." *Cybor*, 138 F.3d at 1464 (Mayer, C.J., concurring) (citations omitted).

[14] *See, e.g., Piper Aircraft Co. v. Reyno*, 454 U.S. 235, 266 (1981).

[15] *See, e.g., Colida v. LG Elects., Inc.*, 77 Fed. Appx. 523, 525 (Fed. Cir. 2003); *Hamlet v. United States*, 873 F.2d 1414, 1416 (1989).

tions,[16] all other causes in equity,[17] a finding of inequitable conduct in patent cases,[18] an award of attorney's fees,[19] and the admissibility of scientific expert testimony,[20] the district courts routinely are called upon to decide non-jury, "legal" issues by making findings as to underlying fact based on the evidence presented by the parties. *All findings of fact by the district courts in such cases are subject to the clearly erroneous standard of Rule 52 or an abuse of discretion standard.*

B. The *De Novo* Standard Is Irreconcilable With A Most Basic Tenet of Patent Law—Claims Must Be Assessed, on A Factual Basis, Through the Lens of A Person of Ordinary Skill in the Art

The Federal Circuit majority's decisions are irreconcilably in conflict with one of the most basic tenets of patent law—that patent claims must be interpreted through the lens of a "person of ordinary skill in the art."[21]

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[16] *See, e.g., Zenith Radio Corp. v. Hazeltine Research, Inc.*, 395 U.S. 100, 108 (1969); *United States v. Oregon State Medical Soc.*, 343 U.S. 326, 332 (1952); *Nat'l Steel Car, Ltd. v. Canadian Pacific Ry., Ltd.*, 357 F.3d 1319, 1325 (Fed. Cir. 2004).

[17] *See, e.g., United States v. United States Gypsum Co.*, 333 US 364, 395 (1948); *Ecolab, Inc. v. Envirochem, Inc.*, 264 F.3d 1358 (Fed. Cir. 2001).

[18] *See, e.g., Duro-Last, Inc. v. Custom Seal, Inc.*, 321 F.3d 1098, 1110 (Fed. Cir. 2003).

[19] *See, e.g., Glaxo Group Ltd. v. Apotex, Inc.*, 376 F.3d 1339, 1364 (Fed. Cir. 2004).

[20] *See, e.g., Gen. Elec. v. Joiner*, 522 U.S. 136, 138-39 (1997).

[21] *See generally*, 5A DONALD S. CHISUM, CHISUM ON PATENTS § 18.03 (2003); *see also, e.g., Multiform Desiccants, Inc. v. Medzam, Ltd.*, 133 F.3d 1473, 1477 (Fed. Cir. 1998) ("It is the person of ordinary skill in the field of the invention through whose eyes the claims are construed. Such person is deemed to read the words used in the patent documents with an understanding of their meaning in the field, and to have knowledge of

The "person of ordinary skill" standard is a bedrock principle of patent law, its standing and authority similar to that of a constitutional provision. It is an across-the-board requirement whenever patent claims are to be understood, interpreted, and tested by judges. The "person of ordinary skill" standard governs not only claim interpretation, but the issues of obviousness, indefiniteness, and enablement as well. *See Graham v. John Deere Co.*, 383 U.S. 1, 37 (1966); *BJ Servs. Co. v. Halliburton Energy Servs., Inc.*, 338 F.3d 1368, 1371 (Fed. Cir. 2003); *Newell Cos., Inc. v. Kenney Mfg. Co.*, 864 F.2d 757, 779 (Fed. Cir. 1988).

To comply with this rule, district courts *must* use extrinsic evidence, and they *must* engage in fact-finding. Virtually no federal judge is competent to read and understand a patent and its prosecution history without resorting to such outside aid and assistance. As Judge Newman has observed:

> The value of extrinsic evidence in claim interpretation is not surprising, because patent documents are written by and for persons in the field of the invention, not for judges. Judges not only need a larger understanding of the science or technology, but we also need help with understanding how the particular terms as used in the patent are viewed by persons in the field of the invention.[22]

No matter how many *en banc* opinions the Federal Circuit may render, it cannot alter this truth.

How the person of ordinary skill in these cases would construe a patent claim has long been understood to involve

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any special meaning and usage in the field. The inventor's words that are used to describe the invention—the inventor's lexicography—must be understood and interpreted by the court as they would be understood and interpreted by a person in that field of technology.")

[22] *Cybor*, 138 F.3d at 1480.

questions of fact. As Judge Learned Hand stated: "The question was of how the art understood the term, which was plainly a question of fact; and unless the finding was 'clearly erroneous,' we are to take this definition as controlling. It is an issue which we are altogether incompetent to decide upon the merits . . . ."[23] As Judge Newman has pointed out, moreover, the Federal Circuit cannot simply transmute facts into non-facts by simple fiat:

> The legal construction of documents—patent documents and other documents—is indeed a matter of law. The legal effect of the patent claim is to establish the metes and bounds of the patent right to exclude; this is a matter of law. But this does not deprive the underlying facts of their nature as fact. These facts are found on evidence that includes the patent specification, relevant prior art, the prosecution history, the testimony of experts in the field, and other relevant evidence such as tests and demonstrations . . . . *These findings do not become rules of law because they relate to a document whose legal effect follows from the found facts.*[24]

In creating the Federal Circuit, Congress made clear that it did not want this fact-finding responsibility of the district courts curtailed, specifically pointing out that the "technical issues of a patent case are factual issues."[25] The Federal Circuit lacks the most basic tools for discovering, collecting and eliciting these facts.

In accord with the views of Judges Hand and Newman of the fact-finding inherent to the claim construction process, this Court stated in its *Graver Tank* opinion: "To no type of

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[23] *Harries v. Air King Prods. Co.*, 183 F.2d 158, 164 (2d Cir. 1950).

[24] *Markman*, 52 F.3d at 1000 (Newman, J., dissenting) (emphasis added).

[25] H.R. REP. NO. 97-312, at 37 (1981).

case is [Rule 52] . . . more appropriately applicable than to the [patent case] before us, where the evidence is largely the testimony of experts as to which a trial court may be enlightened by scientific demonstrations." *Graver Tank & Mfg. Co. v. Linde Air Prods. Co.*, 336 U.S. 271, 274 (1949). In short, when a district court, using the "person of ordinary skill" as a lantern, scans and reviews the contradictory evidence and inferences, assesses the credibility of witnesses, and then makes its findings, it is performing the "very essence of its function" as a *finder of fact. Tennant v. Peoria & P.U. Ry. Co.*, 321 U.S. 29, 35 (1944).

The Federal Circuit is hardly ignorant of this bedrock tenet of patent law. It pays homage to the principle in virtually every case it decides, including this one. *See* App., *infra* at 9a. But while the Federal Circuit gives the rule tremendous lip service, it has, subsequent to its adoption of the *de novo* standard, totally ignored it. It could not do otherwise, as the two principles are fundamentally in conflict. As one Federal Circuit judge has observed, "[a]s this court verbally recognizes but substantively ignores, the understanding of one of ordinary skill in the art sets the proper context for the meaning of claim terms." *K-2 Corp. v. Salomon S.A.*, 191 F.3d 1356, 1370 (Fed. Cir. 1999) (Rader, J., dissenting).

In the end, the *de novo* standard simply cannot withstand the most elementary of tests. It violates precedent and lacks logical consistency. It is clearly not justified by the notion that courts do not take evidence when they are deciding legal issues. And it is unavoidably in conflict with the requirement that claim construction, "plainly [being] of fact," be performed by the district court through the lens of a "person of ordinary skill"—a fundamentally factual endeavor. Chief Judge Mayer has bluntly made the point that the Federal Circuit's adoption of a *de novo* standard is

a result of "insular dogmatism inspired by unwarranted elitism." *Markman*, 52 F.3d at 989 (Mayer, J., concurring). Likewise, Judge Rader has observed that the Federal circuit has "*sub silentio* redefined" the hallowed test of a "person of ordinary skill in the art" with a new test—"how [a] lawyer or judge would interpret the term." *Cybor*, 138 F.3d at 1475 (Rader, J., dissenting).

II. The Reversal Rate Occasioned by the *De Novo* Standard Is Unprecedented and Antithetical to the Orderly and Fair Administration of Justice

The damage that the *de novo* standard has inflicted on the patent system, and therefore innovation, is massive by any measure.

The *de novo* standard has led to an unheard of rate of reversals of district court decisions. Since this Court's decision in *Markman*, multiple studies have shown that the Federal Circuit has reversed approximately 30-40 percent of district court claim constructions.[26] *In some years, this rate has hovered at the staggering rate of 50 percent. See Cybor*, 138 F.3d at 1476 (Rader, J., dissenting). The reversal rate in appeals that focus on claim construction issues is nearly twice as high as the Federal Circuit's overall reversal rate.[27] *It is nearly five times as high as the average reversal rate for all courts of appeals nationwide.*[28] Only the most ardent worshipers of the *status quo* and the

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[26] *See, e.g.*, Kimberley A. Moore, *Are District Court Judges Equipped to Resolve Patent Cases?*, 15 HARV. J. L. & TECH. 1, 11-12 (2001); Chu, *supra* note 12, at 1100; *Cybor*, 138 F.3d at 1476 (Rader, J., dissenting).

[27] *See* Moore, *supra* note 26, at 11-12.

[28] *See* ADMIN. OFF. OF THE U.S. CTS., FED. JUD. CASELOAD STAT. Table B-5: *U.S. Courts of Appeals—Appeals Terminated on the Merits, by Circuit, During the 12-Month Period Ending March 31, 2003*, *available at* http://www.uscourts.gov/caseload2003/tables/B05Mar03.pdf

bureaucratic rationalizations it fosters would contend that the *de novo* standard has not plunged the patent system into crisis. In the absence of any means to secure regular review of its decisions, the Federal Circuit has engaged in capricious and whimsical "do-overs" of district court fact-finding—precisely the danger chief judge Mayer was referring to when he warned that a *de novo* standard would allow the court to ". . . do pretty much what[ever] it wants. . . ." *Markman*, 52 F.3d at 993 (Mayer, J., concurring).

This Court's decision in *Markman* was meant to *enhance* certainty by giving the claim construction job to judges. The reversal rate engendered by the *de novo* standard "reverses more than the work of numerous trial courts; it also reverses the benefits of *Markman*." *Cybor*, 138 F.3d at 1476 (Rader, J., dissenting). The *de novo* standard substantially delays the point in time when an authoritative claim construction emerges. Given the reversal rate, competitors and others cannot rely on decisions by the district courts. They must wait until the full trial proceeding is concluded, and the Federal Circuit issues its decision on appeal. *See id.* Even then, as in this case, the Federal Circuit's effort at claim construction, far from enhancing certainty, may effectively rewrite the claim in such a manner that its meaning remains unclear or becomes more unclear; and, as noted, the Federal Circuit designates some forty percent of its claim construction decisions as non-precedential. As Judge Newman has succinctly explained: "[W]hen the technologic issues are complex, appellate fact-finding is probably the least effective path to accurate decisionmaking. . . . Appellate briefs and fifteen minutes per side of attorney argument are not designed for *de novo* findings of disputed technologic questions." *Markman*, 52 F.3d at 999 (Newman, J., dissenting).

III. The Massive Uncertainty Created by the *De Novo* Standard Substantially Impedes Settlements

The uncertainty fostered by the Federal Circuit's adoption of the *de novo* standard has created a disincentive to settlement of patent cases.[29] Only when the parties know the meaning of patent claims, can they more reasonably predict the outcome of the litigation and the expected value of a judgment for the patentee, and arrive at a settlement to save the costs of litigation. *See Cybor*, 138 F.3d at 1475-76 (Rader, J., dissenting). As Chief Judge Posner of the Seventh Circuit Court of Appeals has pointed out, uncertainty as to outcome is the key to the settlement rate—the more uncertainty, the less chance of settlement. *See* RICHARD A. POSNER, THE FEDERAL COURTS: CHALLENGE AND REFORM, 88-92 (1996). Even judges who were part of the Federal Circuit majorities in *Markman* and *Cybor* recognize the serious adverse effects the *de novo* standard has on settlements. As Judge Michel, who voted with the majority in both *Markman and Cybor*, has written: "[U]ntil a panel of the Court of Appeals for the Federal Circuit decides the case, no one can know the correct outcome, and the trial court result will not be seen as acceptable. As a result, cases will be settled less often before the institution of proceedings, (*i.e.*, the filing of a complaint)."[30] For example, of the approximately 11,000 patent cases filed from 1995-

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[29] *See* William F. Lee & Anita K. Krug, *Still Adjusting to* Markman: *A Prescription for the Timing of Claim Construction Hearings*, 13 HARV. J. L. & TECH. 55, 70 (1999) (stating that district court "'judge's interpretations of patent claims have often spurred intransigence rather than a rush to settle.'")(quoting Margaret Cronin Fisk, *Confusion Follows '96 Landmark Patent Case*, NAT'L L.J., June 15, 1998, at A20).

[30] Hon. Paul R. Michel, *The Court of Appeals for the Federal Circuit Must Evolve to Meet the Challenges Ahead*, 48 AM. U. L. REV. 1177, 1191 (1999).

1999, more than half failed to settle in the first 12 months. One study showed a significant difference in the likelihood of settlement in patent cases as compared to other civil suits—only 76 percent of patent cases settle, as compared to 95 percent of other types of commercial suits.[31]

The disincentive to settlement has another material adverse effect. It clogs an overworked federal judiciary. The number of patent cases filed each year has grown by approximately 53 percent in the period from 1996-2003,[32] while there was a 6 percent decline in the rate of new filings for civil suits overall.[33] The termination rate of patent cases has not kept pace with the explosion in new filings. The average patent case now takes five years to litigate.[34] Accordingly, the federal judiciary has seen a 40 percent increase in pending patent cases.[35] This is compared with

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[31] *See* FROM IDEAS TO ASSETS: INVESTING WISELY IN INTELLECTUAL PROPERTY 328 (Bruce Berman, ed.) (2002); Brian C. Haussmann, *Notes: The ABA Ethical Guidelines for Settlement Negotiations: Exceeding the Limits of Adversarial Ethics*, 89 CORNELL L. REV. 1218, 1220 (2004).

[32] The number of patent cases filed increased from 1,840 in 1996 to more than 2,800 in 2003. *See* Gauri Prakash-Canjels, *Trends in Patent Cases: 1990-2000*, 41 IDEA 283 (2001); Timothy Aeppel, *Patent Dispute Embroils Host of Industries*, WALL ST. J., October 21, 2004, at B1.

[33] *Compare* U.S. SUP. CT., CHIEF JUSTICE'S YEAR-END REP. ON THE FED. JUDICIARY (1996), *available at* http://www.uscourts.gov/cj96.htm *with* U.S. SUP. CT., CHIEF JUSTICE'S YEAR-END REP. ON THE FED. JUDICIARY (2003), *available at http://www.supremecourtus.gov/publicinfo/year-end/2003year-endreport.html*.

[34] *See* S. Jay Plager, *Challenges for Intellectual Property Law in the Twenty-First Century: Indeterminacy and Other Problems*, 2001 U. ILL. L. REV. 69, 75 (2001).

[35] *See* Prakash-Canjels, *supra* note 32, at 287. The percentage increase was calculated based on the increase in the number of pending patents cases from 1995 to 2000; the 1996 statistics were not reported by the Judicial Office of the United States Courts. *See id.*

an approximate 2 percent increase in pending civil cases over the same time period.[36] In short, fewer and fewer patent cases are being concluded each year, while an ever-increasing number are being filed.

This problem is directly related to the Federal Circuit's adoption of the *de novo* standard with the high reversal rates and the disincentive for settlements it engenders. The waste and inefficiency detailed above is what follows from a court of appeals moonlighting as a district court. This Court all but predicted such problems in its *Anderson* decision: "Duplication of the trial judge's efforts in the court of appeals would very likely contribute only negligibly to the accuracy of fact determination at a huge cost in diversion of judicial resources." *Anderson v. Bessemer City*, 470 U.S. 564, 574-75 (1985).

IV. The *De Novo* Standard Has Occasioned A Substantial Increase in the Cost of Patent Litigation

The lack of deference paid to district court claim constructions under the Federal Circuit's *de novo* standard increases litigation costs even as it reduces the incentive to settle. The American Intellectual Property Law Association ("AIPLA") has estimated that the median cost for a significant patent litigation is $4 million.[37] This is up from

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[36] *Compare* ADMIN. OFF. OF THE U.S. CTS., FED. JUD. CASELOAD STAT. Table C: *U.S. District Courts—Civil Cases Commenced, Terminated, and Pending During the Twelve-Month Periods Ended September 30, 1996* and 1997, *available at*, http://www.uscourts.gov/judicial_business/c00sep97.pdf *with* ADMIN. OFF. OF THE U.S. CTS., FED. JUD. CASELOAD STAT. Table C: *U.S. District Courts—Civil Cases Commenced, Terminated, and Pending During the Twelve-Month Periods Ending December 31, 2000 and 2001*, *available at* http://www.uscourts.gov/judiciary2001/dectables/c00dec01.pdf

[37] *See* AM. INTELL. PROP. L. ASS'N, REP. OF THE ECON. SURV. (2003).

the approximately $1 million the AIPLA estimated it cost in 1995, the year that the Federal Circuit decided *Markman.*[38] It has been estimated that the patent cases filed in the year 2000 alone will generate $4.2 billion in legal fees and costs.[39]

The Federal Circuit's adoption of the *de novo* standard has contributed to this dramatic increase in the costs of patent litigation, both by discouraging settlements and lengthening the actual time spent in trial. *See Cybor,* 138 F.3d at 1475-76 (Fed. Cir. 1998) (Rader, J., dissenting). As the outcome of claim construction hearings can lead to dispositive summary judgment motions, millions of dollars in litigation costs could potentially be saved if Rule 52 applied, as it did pre-*Markman. Id.* Under the *de novo* standard, as this case illustrates, a meritorious summary judgment at the district court level is converted into an expensive and non-productive stop on the road to a lengthy trial. *Id.* It is an inefficient system.

Imposing higher than necessary litigation costs on the patent system is inimical to its core purpose.[40] In order to promote innovation, the patent system gives economic incentives to inventors in the form of a limited monopoly. The more expensive it is to enforce a patent through patent infringement litigation, the less valuable the patent is, and the less powerful the incentive to participate in the patent system. The exploding costs of patent litigation and the uncertainty created by the Federal Circuit's *de novo* standard, place unwarranted obstacles in the path of innovation. The increased costs of patent litigation caused by

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38 *See* AM. INTELL. PROP. L. ASS'N, REP. OF THE ECON. SURV. (1995).

39 *See* Berman, *supra* note 31, at 334.

40 U.S. CONST. art. I, § 8, cl. 8. (Congress shall have the power "[t]o promote the Progress of Science and useful Arts. . . .")

Markman weaken the very foundation of our patent system by decreasing the effectiveness of its basic incentives.

V. The *De Novo* Standard Is Undermining the Credibility and Perceived Legitimacy of the Federal Circuit and the Patent System

The hopelessly flawed *de novo* standard has done more than simply waste the judicial resources of the district courts, and the time and money of litigants. It has also undermined the credibility of the Federal Circuit itself. As the foregoing analysis shows, the reality is that neither the district courts nor the Federal Circuit are capable of heeding, in practice, the prohibitions on the use of extrinsic evidence. Nonetheless, the fiction is maintained, indeed protected, as vigorously as the notion of the Emperor's beautiful wardrobe. In the real world, however, because a district court will look to minimize the potential of being reversed, the *de novo* standard tends to incentivize judges, consciously or not, to go along with the fiction and conceal their reliance on extrinsic evidence. This framework injects an insidious element into the system, corroding its foundation, and inflicting irreparable harm on the credibility and perceived legitimacy of the Federal Circuit. Former Judge Schwartz of the District of Delaware—one of the busiest patent courts in the country—made this point when, calling the *de novo* standard "sophistry and fiction," he discussed the standard's surrealistic assumption that a district court can somehow use extrinsic evidence to "understand the technology" and can then proceed to resolve a claim interpretation dispute without accessing any of the extrinsic evidence to which he has been privy—evidence, it should be added, that forms the sole basis upon which he has come to understand the patent issues at all:

> If those possessed of a higher commission wish to rely on a cold written record and engage in *de novo* review of all claim constructions that is their privilege. But when the Federal Circuit states that the trial court does not do something that the trial court does and must do to perform the judicial function, that court knowingly enters a land of sophistry and fiction. As a consequence, bound by slavish adherence to the fiction that a judge does not make credibility determinations when confronted with testimonial extrinsic evidence *en route* to pronouncing the "true" meaning of a patent claim, this opinion has been crafted in a manner that leaves the reader, and the reviewing court, uninformed as to the credibility assessments which, as always, are necessary precursors to the acceptance or rejection of testimonial evidence from competing experts.[41]

Judge Rader of the Federal Circuit has been concerned about the same problem, labeling it a "perverse incentive":

> In practice, how does this court's lofty appellate logic work? As this court acknowledges, a trial court must often resort to experts to learn complex new technologies. What happens when that learning influences a trial judge's interpretation of the claim terms? *Are trial judges supposed to disguise the real reasons for their interpretation? How will this perverse incentive to "hide the ball" improve appellate review?*

Cybor, 138 F.3d at 1474 (Rader, J., dissenting) (emphasis added).

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[41] *Lucas Aerospace, Ltd. v. Unison Indus., L.P.*, 890 F. Supp. 329, 333-34 n. 7 (D. Del. 1995) (citations omitted).

Compounding these problems is the fact that there is no judicial body to review the Federal Circuit's actions (save this Court through a *certiorari* petition). Chief Judge Mayer has noted this additional concern, stating:

> If claim construction is only a question of law to be reviewed by this court *de novo*, then the absence of review as a matter of right over *our* claim constructions, which may be new and unsupported by legal analysis, or may never have been tested by the adversarial process, would transform this court into a trial court of first and usually last resort.

Id. at 1466 (Mayer, C.J., dissenting) (emphasis in original).

CONCLUSION

For the foregoing reasons, this Petition for a writ of *certiorari* should be granted.

Respectfully submitted,

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APPENDIX

APPENDIX A

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

04-1116
Decided: August 27, 2004

DANA CORPORATION,

Plaintiff-Appellant,

—v.—

AMERICAN AXLE & MANUFACTURING, INC.,

Defendant-Appellee.

2004 U.S. App. LEXIS 18265

Before

MICHEL, *Circuit Judge*, ARCHER, *Senior Circuit Judge*, and RADER, *Circuit Judge*.

OPINION

MICHEL, *Circuit Judge*.

Plaintiff-Appellant Dana Corporation ("Dana") appeals from an order granting summary judgment of non-infringement to American Axle & Manufacturing, Inc. ("AAM") based on a finding that no reasonable jury could find that AAM's accused products literally infringe the

asserted claims of United States Patent Nos. 5,637,042 and 5,643,093 ("the '042 patent" and "the '093 patent," respectively), and that Dana's claim of infringement under the doctrine of equivalents was barred by prosecution history estoppel. *Dana Corp. v. Am. Axle & Mfg.*, 2003 U.S. Dist. LEXIS 25845, No. 98-74521 (E.D. Mich. Oct. 28, 2003) ("Summary Judgment Order"). Because we find that the district court erred in its construction of the disputed claim limitation, and thus in its finding of no literal infringement as a matter of law and erred in finding a prosecution history estoppel bar, we vacate the judgment of the district court and remand the case for further proceedings consistent with this opinion.

BACKGROUND

Dana is the assignee of the patents-in-suit, which are directed to swaged vehicle driveshafts with a diameter reducing portion "having a substantially uniform wall thickness." The invention of '093 patent is described as: A driveshaft includes a center portion having a larger diameter, an end portion having a reduced diameter, and a diameter reducing portion positioned between the center and end portions. The reduced diameter end portion of the driveshaft is secured to a reduced diameter tube yoke. This facilitates the introduction of tooling during assembly of a universal joint. The driveshaft is formed by a method which involves first heat treating the driveshaft to a relatively soft temper, then swaging the end portion of the driveshaft, and then heat treating the driveshaft again to a relatively hard temper. In more detail, a driveshaft is provided having a predetermined first diameter, the driveshaft being heat treated to achieve a relatively soft temper so as

to possess a desired elongation factor. This allows the end portion of the driveshaft to be swaged to reduce the diameter thereof to a second predetermined diameter. After swaging, the driveshaft is heat treated again to achieve a relatively hard temper to meet the strength requirements for use. '093 patent, Abstract. Claim 1 of the '093 patent is as follows: 1. A drive line assembly comprising:

> a driveshaft robe formed from a metallic material and including a homogeneous diameter reducing portion having a substantially uniform wall thickness, said diameter reducing portion including an axially extending cylindrical first end extending from said driveshaft tube, said diameter reducing portion further including an axially extending cylindrical second end, said axially extending cylindrical first end of said diameter reducing portion defining a first diameter, said axially extending cylindrical second end of said diameter reducing portion defining a second diameter, said first diameter being larger than said second diameter; and
>
> a tube yoke formed from a metallic material and including an axially extending cylindrical end portion having a substantially uniform wall thickness which is co-axial with and permanently fixed to said axially extending cylindrical second end portion of said diameter reducing portion of said driveshaft tube, said tube yoke further including a pair of opposed lug ears extending from said end portion and having respective orifices formed therethrough. '093 patent, claim 1 (emphases added).

Similarly, the invention of the '042 patent is described as: A drive line assembly includes a cylindrically shaped driveshaft tube and a tube yoke, one end of the driveshaft tube fitting over the tube yoke in an interference fit sufficient to transfer torque between the driveshaft tube and the tube yoke, the tube yoke comprising a tube seat at one end for mating in a torque transferring relationship with the end of the driveshaft. The other end of the driveshaft tube yoke has a lug structure for transferring torque to other rotatable elements through a universal joint. The tube yoke has a diameter reducing portion intermediate the tube seat and the lug structure so that the lug structure is smaller in diameter than the drive shaft tube and the tube seat to facilitate the introduction of tooling to the lug structure during assembly operations of the universal joint. '042 patent, Abstract. Claim 1 of the '042 patent is as follows: 1. A drive line assembly comprising:

> a driveshaft tube formed from a metallic material and having a substantially uniform wall thickness, said driveshaft tube terminating in an axially extending cylindrical end portion;
>
> a diameter reducing portion formed from a metallic material and having a substantially uniform wall thickness, said diameter reducing portion including an axially extending cylindrical first end which is coaxial with and permanently fixed to said axially extending cylindrical end portion of said driveshaft tube, said diameter reducing portion further including an axially extending cylindrical second end, said axially extending cylindrical first end of said diameter reducing portion defining a first diameter, said axially extending cylindrical second end of said diameter

> reducing portion defining a second diameter, said first diameter being larger than said second diameter; and
>
> a tube yoke formed from a metallic material and including a pair of opposed lug ears having respective orifices formed therethrough, said tube yoke including an axially extending cylindrical end portion which is co-axial with and permanently fixed to said axially extending cylindrical second end of said diameter reducing portion for axial and rotational movement therewith. '042 patent, claim 1 (emphases added). Independent claim 11 of the '042 patent is also directed to a driveline assembly "having a substantially uniform wall thickness." '042 patent at 6:1-3.

Dana sued AAM for the alleged infringement of claims 1-7 of the '093 patent and claims 1-19 of the '042 patent. AAM moved for summary judgment of invalidity based on the pre-critical date activities of Dana and other companies. On September 1, 2000, the district court granted AAM's motions for summary judgment finding that all claims of both patents were invalid under section 102(b) based on independent pre-critical date activities of General Motors and Dana, stating that "the only claim at issue is whether the diameter of the reducing portion of the swaged ends has a 'substantially uniform wall thickness.'" The district court denied AAM's motion for summary judgment of unenforceability.

Dana appealed to this court, which vacated summary judgment and remanded to the district court. *Dana Corp. v. American Axle & Mfg., Inc.*, 279 F.3d 1372 (Fed. Cir. 2002). This court concluded that the district court had erred in failing to construe and apply the "substantially

uniform wall thickness" limitation before granting summary judgment of invalidity, vacated the entry of summary judgment, and remanded the case to the district court for further proceedings. *Id.* at 1377.

On remand, the district court held a claim construction hearing. On March 3, 2003, the district court issued an Order Regarding Claim Interpretation, construing three claim limitations, namely, "substantially uniform wall thickness," "diameter reducing portion," and "about five inches." *Dana Corp. v. Am. Axle & Mfg.*, 2003 U.S. Dist. LEXIS 25844, No. 98-74521 (E.D. Mich. Mar. 3, 2003) ("Order Regarding Claim Interpretation"). The court interpreted the term "substantially uniform wall thickness" to mean "a wall thickness that does not vary more than the wall variation in the tube wall before swaging." 2003 U.S. Dist. LEXIS 25844 at *4. More specifically, the court wrote: During prosecution of the patent applications, plaintiff Dana amended the claims by addition of the term "substantially uniform wall thickness" in the diameter reducing portion. There is no textual description or discussion of this claim element in the specification of the patents. The only reference pointed to by Dana is the drawings, which show the wall thickness designated by parallel lines, *i.e.*, equal thickness throughout. This would be the common meaning of the term. Since no other meaning is specifically given or pointed to in the specification, the common meaning should be used.

Likewise, in the Petition to Make Special for the '093 patents, Dana characterized the prior art where a tube is swaged on a mandrel to control the inner diameter as having substantially uniform wall thickness. See *Gentry Gallery, Inc. v. Berkline Corp.*, 134 F.3d 1473, 1477 (Fed. Cir. 1998). This is contrasted to an uncontrolled inner

diameter produced by normal swaging, which was non-uniform wall thickness. This limitation was subsequently added to the claims to overcome prior art rejections based on normally swaged shafts.

Therefore, the court interprets the phrase "substantially uniform wall thickness" as used in the patents as meaning a wall thickness that does not vary more than the wall variation in the tube wall before swaging. 2003 U.S. Dist. LEXIS 25844 at *3-*4.

On October 29, 2003, the district court granted AAM's motion for summary judgment of noninfringement, based solely on the "substantially uniform wall thickness" claim limitation. Specifically, the court held that, even accepting Dana's contention as to how much variation in wall thickness constitutes the manufacturing tolerance, "the wall thickness in the swaged portion of the accused device varies more than the wall thickness before swaging." Summary Judgment Order, 2003 U.S. Dist. LEXIS 25845 at *7. Therefore, the district court found, "since a claim element is absent from the accused product, there is no literal infringement." *Id.* With regard to infringement under the doctrine of equivalents, the district court found that because the "substantially uniform wall thickness" limitation was added to the claims to overcome prior art rejections based on normally swaged shafts, prosecution history estoppel applied and the doctrine of equivalents was not available to Dana. 2003 U.S. Dist. LEXIS 25845 at *9. The district court entered judgment in favor of AAM on November 6, 2003.

Dana timely appealed. We have jurisdiction pursuant to 28 U.S.C. § 1295(a)(1).

This opinion follows the court's review of the record and briefs, and consideration of the parties' oral argument, heard on August 4, 2004.

DISCUSSION

We review *de novo* a district court's grant of summary judgment. *Ethicon Endo-Surgery, Inc. v. United States Surgical Corp.*, 149 F.3d 1309, 1315 (Fed. Cir. 1998). Summary judgment is appropriate if, drawing all factual inferences in favor of the non-movant, he cannot show there is a genuine issue of material fact and the movant is entitled to judgment as a matter of law. Fed. R. Civ. P. 56(c); *Anderson v. Liberty Lobby, Inc.*, 477 U.S. 242, 255, 91 L. Ed. 2d 202, 106 S. Ct. 2505 (1986).

Analysis of infringement involves two steps. *Johnson Worldwide Assocs., Inc. v. Zebco Corp.*, 175 F.3d 985, 988 (Fed. Cir. 1999). First, the trial court determines the scope and meaning of the asserted claims. *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 372-74, 134 L. Ed. 2d 577, 116 S. Ct. 1384 (1996). The trial court's claim construction is an issue of law reviewed without deference. *Cybor Corp. v. FAS Techs., Inc.*, 138 F.3d 1448, 1456 (Fed. Cir. 1998) (en banc). Second, the claims as construed by the court are compared limitation by limitation to the features of the allegedly infringing device. *Johnson Worldwide*, 175 F.3d at 988. We affirm a district court's grant of summary judgment of non-infringement only if, "after viewing the alleged facts in the light most favorable to the non-movant, there is no genuine issue whether the accused device is encompassed by the claims." *Pitney Bowes, Inc. v. Hewlett-Packard Co.*, 182 F.3d 1298, 1304 (Fed. Cir. 1999).

On appeal, Dana challenges both the claim construction ordered by the district court and the resultant grant of summary judgment of non-infringement. We address these challenges below.

I.

The language of the claim defines the boundary of its scope. *Teleflex, Inc. v. Ficosa N. Am. Corp.*, 299 F.3d 1313, 1324 (Fed. Cir. 2002). Accordingly, "the claim construction inquiry ... begins and ends in all cases with the actual words of the claim." *Id.* (quoting *Renishaw PLC v. Marposs Societa' per Azioni*, 158 F.3d 1243, 1248 (Fed. Cir. 1998)). Claim terms must be construed as they would be understood by a person of ordinary skill in the art to which the invention pertains. *Specialty Composites v. Cabot Corp.*, 845 F.2d 981, 986 (Fed. Cir. 1988). What the claim terms would mean to laymen is irrelevant. "The words used in the claim[] are interpreted in light of the intrinsic evidence of record, including the written description, the drawings, and the prosecution history, if in evidence." *Teleflex*, 299 F.3d at 1324.

Here, we agree with Dana that the district court erred in construing the limitation "substantially uniform wall thickness" to mean a "wall thickness that does not vary more than the wall variation in the tube wall before swaging." We hold that "substantially uniform wall thickness" is properly construed to mean that the wall of the tube is largely or approximately uniform in thickness, but may vary at least as much as the wall thickness varied prior to swaging plus the variation in wall thickness that necessarily results from swaging the tube in accordance with the claimed invention of the '093 and '042 patents.

Looking first to the claim language itself, we are persuaded by Dana's argument that the limitation "substantially uniform wall thickness" must allow for variation in wall thickness greater than the pre-swaging variation in order to give meaning to the term "substantially." The pre-swaging manufacturing tolerance is a manufacturing reality that would have to be encompassed within the claim even if the modifier "substantially" was not used; otherwise, no real-world embodiment, including the patentee's own embodiment, could fall within the scope of the claim. The use of the modifier "substantially" signals that the claim drafter intended the scope of the claims of the patents-in-suit to allow for some variation greater than that variation that necessarily exists in any driveshaft claims due to simple manufacturing realities.

The term "substantially" is commonly used by claim drafters to indicate approximation. See *Cordis Corp. v. Medtronic AVE Inc.*, 339 F.3d 1352, 1360 (Fed. Cir. 2003) ("The patents do not set out any numerical standard by which to determine whether the thickness of the wall surface is 'substantially uniform.' The term 'substantially,' as used in this context, denotes approximation. Thus, the walls must be of largely or approximately uniform thickness."); see also *Deering Precision Instruments, LLC v. Vector Distribution Sys., Inc.*, 347 F.3d 1314, 1322 (Fed. Cir. 2003) ("Indeed, our cases recognize the dual ordinary meaning of this term as connoting a term of approximation or a term of magnitude."); *Epcon Gas Sys., Inc. v. Bauer Compressors, Inc.*, 279 F.3d 1022, 1031 (Fed. Cir. 2002). We find that the term "substantially" was used in just such a manner in the claims of the patents-in-suit: "substantially uniform wall thickness" denotes a wall thickness with approximate uniformity.

Nothing in the specification confirms or conflicts with this construction. Indeed, the district court found, and the parties agree, that the written descriptions of the '093 and '042 patent are not helpful in construction of the disputed limitation because neither written description addresses wall thickness of the driveshaft tube, and the '042 patent's written description does not even describe the swaging process. We agree. With regard to the drawings in the patents-in-suit, we are persuaded by Dana's argument that the district court erred in relying on these drawings to limit the scope of the claims to only pre-swaging wall thickness variations. That the drawings of the patents delineate walls with parallel lines does not require that the claims be limited to tubes with wall thicknesses that are perfectly uniform except for pre-swaging manufacturing tolerances: the reduced size of the drawings (which are not drawn to scale to begin with) makes variation in wall thickness imperceptible. Moreover, even if the drawings were a reliable indicator of wall thickness variations in particular embodiments, that alone would not warrant limiting the claims to the wall thickness variation depicted therein.

We next turn to the prosecution histories of the patents-in-suit for guidance as to the construction of the limitation "substantially uniform wall thickness." As noted above, the district court found that, in the Petition to Make Special for the '093 patent, Dana characterized the prior art where a tube is swaged on a mandrel to control the inner diameter as having substantially uniform wall thickness, in contrast to an uncontrolled inner diameter produced by normal swaging, which was a non-uniform wall thickness. Order Regarding Claim Interpretation, 2003 U.S. Dist. LEXIS 25844 at *3-*4. Accordingly, the district court found that the "substantially uniform wall thickness" limi-

tation was added to the claims to overcome prior art rejections based on normally swaged shafts (*i.e.*, shafts swaged without an inner mandrel). *Id.* We disagree with the district court's interpretation of the prosecution history.

In the Petition to Make Special, the patentee argued: U.S. Patent No. 3,854,316 to Wilson discloses a method of forming a hollow aluminum baseball bat having a substantially uniform thickness. Initially, a hollow cylindrical tube blank is extruded or drawn so as to have a constant diameter and thickness. Then, a longitudinal portion of the tube is placed on a mandrel having a constant outer diameter which corresponds to the inner diameter of the handle portion of the bat to be formed. Next, the handle portion of the tube is reduced, such as by swaging, to provide reduced outer and inner diameters and a substantially uniform thickness. During this reduction step, the longitudinal relationship between the tube and the mandrel is maintained.... U.S. Patent No. 3,479,030 to Merola discloses a similar method. These patents clearly relate to a non-analogous field of art (baseball bats) relative to the claimed invention (driveshaft tubes for vehicles) and would not have been considered by a person having ordinary skill in the art. We do not agree with the district court that this language constitutes a distinction between a shaft swaged with an inner mandrel (substantially uniform) and a shaft swaged without an inner mandrel (non-uniform). Indeed, the patentee characterized the entire bat as having a substantially uniform wall thickness. This is fully consistent with the Wilson reference itself, which teaches "[a] method of making a hollow metal ball bat having a wall thickness along the length thereof that is substantially uniform," regardless of whether the longitudinal portion was swaged with an inner mandrel. See U.S. Patent No.

3,854,316, Abstract (emphasis added). In addition, the remarks accompanying the patentee's amendment to the claims adding the disputed limitation indicate that the patentee sought to distinguish the patented invention on the grounds that the Shinohara reference cited by the examiner did "not disclose a driveshaft tube having a substantially uniform wall thickness throughout the central portion and the end portion." Thus, we cannot agree with the district court that the "substantially uniform wall thickness" limitation was added to distinguish normally-swaged shafts from shafts swaged with a mandrel.

Because the patent specification and prosecution history provide no specific numerical guidance as to the range encompassed by the term "substantially," and because we do not find convincing the scant expert testimony cited by the parties, we do not construe the limitation "substantially uniform wall thickness" as having any specific numerical range. Instead, we hold that "substantially uniform wall thickness" is properly construed to mean that the wall of the tube is largely or approximately uniform in thickness, but may vary at least as much as the wall thickness varied prior to swaging plus the variation in wall thickness that necessarily results from swaging a portion of the tube in accordance with the claimed invention of the '093 and '042 patents.

II.

Because the district court's grant of summary judgment of no literal infringement was premised on its incorrect construction of the disputed limitation, we must vacate the entry of summary judgment. Though our revised construction does not set forth a numerical range of permissible wall thickness variation, this construction should not be

taken as precluding the entry of summary judgment of infringement or non-infringement by the district court in its further proceedings. If the district court finds either infringement or non-infringement as a matter of law (*i.e.*, if the district court finds that no reasonable jury could find that the accused products do not infringe or fail to find they do infringe, respectively) under the correct construction, the entry of summary judgment would be appropriate. Otherwise, a trial on infringement is appropriate.

With regard to the entry of summary judgment of non-infringement under the doctrine of equivalents based on a conclusion of prosecution history estoppel, we must also vacate and remand to the district court. Because, as noted above, the district court erred in holding that the "substantially uniform wall thickness" limitation was added to overcome prior art references teaching normally swaged shafts, its resultant finding of prosecution history estoppel must be vacated.

CONCLUSION

We hold that the district court erred in its construction of the disputed claim term "substantially uniform wall thickness" in the '093 and '042 patents. Because the district court's entry of summary judgment of non-infringement was premised upon an incorrect construction of this limitation, the order granting summary judgment is in all respects

VACATED AND REMANDED.

APPENDIX B

UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF MICHIGAN,
SOUTHERN DIVISION

No. 98-74521
Decided: October 28, 2003

DANA CORPORATION,

Plaintiff,

—v.—

AMERICAN AXLE & MANUFACTURING, INC.,

Defendant.

2003 U.S. Dist. LEXIS 25845

Before

JOHN CORBETT O'MEARA,

United States District Judge.

OPINION AND ORDER GRANTING DEFENDANT'S MOTION FOR SUMMARY JUDGMENT

This matter came before the court on Defendant's April 21, 2003 motion for summary judgment. Plaintiff filed a response on June 9, 2003. Defendant filed a reply on July 21, 2003. Oral argument was heard on October 9, 2003.

BACKGROUND FACTS

This is a patent case involving driveshafts made for GM vans. Driveshafts are used in rear wheel drive cars and trucks and connect the transmission to the rear axle. The driveshafts in issue are swaged, *i.e.*, they have reduced diameter ends compared to the diameter of the midsection of the driveshaft. In 1998, plaintiff Dana Corporation ("Dana") brought suit against defendant American Axle & Manufacturing, Inc. ("AAM") for the alleged patent infringement of its driveshafts.

In 2000, AAM moved for summary judgment of invalidity and non-infringement of the patents. The court granted summary judgment in favor of AAM, holding that the patents were invalid due to "on sale" activities. No decision was rendered on AAM's non-infringement motion in light of the invalidity determination. After Dana appealed, the Federal Circuit vacated the decision and remanded the case for a *Markman* determination to establish the meaning of certain claim terms.

At a July 18, 2002 *Markman* hearing, the parties identified three terms from the patents in suit, U.S. Patent Nos. 5,643,093 and 5,637,042, for which they required the court's interpretation. On March 3, 2003, the court issued an Order Regarding Claim Interpretation. The court's order interpreted the following terms: "substantially uniform wall thickness," "diameter reducing portion," and "about five inches."

AAM claims that the court's interpretation of "substantially uniform wall thickness" leaves a claim element absent from the accused product. Thus, AAM maintains there can be no literal infringement. In addition, AAM

contends that prosecution history estoppel bars the availability of the doctrine of equivalents.

STANDARD OF REVIEW

Pursuant to Rule 56 (c) of the Federal Rules of Civil Procedure, summary judgment may be granted if the "pleadings, depositions, answers to interrogatories, and admissions on file, together with the affidavits, if any, show that there is no genuine issue as to any material fact and that the moving party is entitled to a judgment as a matter of law." See also, *Celotex Corp. v. Catrett*, 477 U.S. 317, 327, 91 L. Ed. 2d 265, 106 S. Ct. 2548 (1986). The movant bears the burden of demonstrating the absence of all genuine issues of material fact. See *Talley v. Bravo Pitino Restaurant, Ltd.*, 61 F.3d 1241, 1245 (6th Cir. 1995). However, the moving party need not produce evidence showing the absence of a genuine issue of material fact. Rather, "the burden on the moving party may be discharged by 'showing'—that is, pointing out to the district court—that there is an absence of evidence to support the nonmoving party's case." *Celotex*, 477 U.S. at 325. The court must view all the evidence in a light most favorable to the nonmovant as well as draw all reasonable inferences in the nonmovant's favor. See *Bender v. Southland Corp.*, 749 F.2d 1205, 1210-11 (6th Cir. 1984).

Once the moving party discharges its burden, the burden shifts to the nonmoving party to set forth specific facts showing a genuine triable issue. See Fed. R. Civ. P. 56(c); *Talley*, 61 F.3d at 1245. To create a genuine issue of material fact, however, the nonmovant must do more than present some evidence on a disputed issue. Consequently, the nonmovant must produce evidence that would be sufficient

to require submission to the jury of the dispute over the fact. See *Lucas v. Leaseway Multi Transp. Serv., Inc.*, 738 F. Supp. 214, 217 (E.D. Mich. 1990).

LAW AND ANALYSIS

A. Literal Infringement

The burden of proof is placed upon the patentee to show infringement. *Carroll Touch, Inc. v. Electro Mechanical Sys., Inc.*, 15 F.3d 1573, 1578 (Fed. Cir. 1993). Patent infringement analysis entails two steps. The first step is determining the meaning and scope of the patent claims asserted to be infringed. The second step is comparing the properly construed claims to the device accused of infringing. *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 976 (Fed. Cir. 1995). If the parties do not dispute any relevant facts regarding the accused product but disagree over which of two possible meanings of the patent claim is the proper one, the question of literal infringement collapses to one of claim construction and is thus amenable to summary judgment. *Athletic Alternatives, Inc. v. Prince Mfg.*, 73 F.3d 1573, 1578 (Fed. Cir. 1996). Literal infringement means that the accused product contains every limitation of the claims. *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 934 (Fed. Cir. 1987). Infringement, both literal and under the doctrine of equivalents, is a question of fact. *Phillips Petroleum Co. v. Huntsman Polymers Corp.*, 157 F.3d 866, 876 (Fed. Cir. 1998).

AAM claims there is no literal infringement. AAM contends that the court's interpretation of "substantially uniform wall thickness" leaves a claim element absent from the accused product. The claim limitation, "substantially uniform wall thickness," concerns the thickness of the

driveshaft tube wall as it reduces in diameter from larger to smaller. The court interpreted the phrase "substantially uniform wall thickness" as meaning "a wall thickness that does not vary more than the wall variation in the tube wall before swaging." *Markman* Order, p. 2.

The variation of the tube wall thickness in the swaged portion must be compared to the manufacturing tolerance. The manufacturing tolerance is the variation of the thickness in the tube wall before swaging. The variation of the wall thickness in the swaged portion of the accused device ranges from 0.13" to 0.031". Defendant's April 21, 2003 motion for summary judgment brief, exhibit 4. There is some dispute, however, regarding the manufacturing tolerance. AAM's evidence claims that the manufacturing tolerance is no more than 0.003". Dana, on the other hand, contends that the variation ranges from 0.006" to 0.009". Regardless of whose data is used, however, applying either party's proposed manufacturing tolerance reveals that the wall thickness in the swaged portion of the accused device varies more than the wall thickness before swaging. Therefore, the accused device does not have a substantially uniform wall thickness. Since a claim element is absent from the accused product, there is no literal infringement.

B. Doctrine of Equivalents and Prosecution History Estoppel

Even though there is no literal infringement, the court must still determine whether there is infringement under the doctrine of equivalents. *Wolverine Worldwide, Inc. v. Nike, Inc.*, 38 F.3d 1192 (Fed. Cir. 1994). The doctrine of equivalents allows a patentee to show infringement of its patent based upon the insubstantial changes of the accused device that were not literally captured by the patent. The

doctrine is limited, however, particularly where the patentee made a narrowing amendment. *Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 137 L. Ed. 2d 146, 117 S. Ct. 1040 (1997); See also *Festo Corp. v. Shoketsu Kinzoku Kahushiki Co., Ltd.*, 535 U.S. 722, 152 L. Ed. 2d 944, 122 S. Ct. 1831 (2002). Prosecution history estoppel serves to limit the doctrine of equivalents by denying equivalents to a claim limitation whose scope was narrowed during prosecution for reasons related to patentability. See *Pioneer Magnetics, Inc. v. Micro Linear Corp.*, 330 F.3d 1352, 66 USPQ2d 1859 (Fed. Cir. 2003). Stated another way, "estoppel arises when an amendment is made to secure the patent and the amendment narrows the patent's scope." *Festo*, 535 U.S. at 736. The Supreme Court recognized that there are some cases "where the amendment cannot reasonably be viewed as surrendering a particular equivalent."[1] *Id.*, 535 U.S. at 725. Whether or not prosecution history estoppel precludes a particular action for infringement by equivalents is a question of law. *CAE Screenplates Inc. v. Heinrich Fiedler GmbH & Co. KG*, 224 F.3d 1308, 1319 (Fed. Cir. 2000).

The court, in its March 3, 2003 Order Regarding Claim Interpretation, held that the "substantially uniform wall thickness" limitation was "added to the claims to overcome prior art rejections based on normally waged shafts."

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[1] The Court held that the patentee can overcome the presumption that prosecution history estoppel bars a finding of equivalents in cases where: (1) the equivalent may have been unforeseeable at the time of the application; (2) the rationale underlying the amendment may bear no more than a tangential relation to the equivalent in question; or (3) there may be some other reason suggesting that the patentee could not reasonably be expected to have described the insubstantial substitute in question. *Festo*, 535 U.S. at 725. Since Dana has not provided sufficient evidence to overcome this presumption, this is moot.

Markman Order, p. 2. In this case, the very limitation at issue is the same limitation that was added to the claims to obtain patentability. Therefore, under both *Warner-Jenkinson* and *Festo*, prosecution history estoppel applies and the doctrine of equivalents is not available.

ORDER

Accordingly, IT IS HEREBY ORDERED that Defendant's April 21, 2003 motion for summary judgment is GRANTED.

John Corbett O'Meara
United States District Judge

Date: 10-28-03

APPENDIX C

UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF MICHIGAN,
SOUTHERN DIVISION

Case No. 98-74521
Filed: March 3, 2003 Decided: March 3, 2003

DANA CORPORATION,

Plaintiff,

—v.—

AMERICAN AXLE & MANUFACTURING, INC.,

Defendant.

2003 U.S. Dist. LEXIS 25844

Before

JOHN CORBETT O'MEARA,

United States District Judge.

ORDER REGARDING CLAIM INTERPRETATION

This matter came before the court on the parties' June 3, 2002 *Markman* submissions. The parties filed responses June 24, 2002; and oral argument was heard July 18, 2002.

At the July 18, 2002 *Markman* hearing, the parties identified three terms[1] from the patents in suit, U.S. Patent Nos. 5,643,093 and 5,637,042, for which they require this court's interpretation. The terms are "substantially uniform wall thickness," "diameter reducing portion," and "about five inches."

The patents in suit concern driveshafts that have a diameter reducing portion near the end. This construction allows the benefits of a large diameter, high strength driveshaft with the clearance advantages of narrower ends for access by powered tooling. The patents discuss narrowing the end of the driveshaft tube by the method know as "swaging" or by reducing the diameter of the yoke by swaging or other metal forming process. Swaging is a well-known method of forming metal tubing which results in substantially uniform weight per unit of length and increased wall thickness in the reduced diameter portion when performed without an internal mandrel. *Aluminum Co. of America v. Amerola Products Corp.*, 552 F.2d 1020, 1022 (3d Cir. 1977).

Conversely, a substantially uniform wall thickness can be achieved during swaging by using an internal mandrel to control thickness. The internal mandrel controls the internal size of the tube and the swaging dies control the external diameter of the tube. See, *e.g.*, U.S. Patent No. 3,854,316 to Wilson.

During prosecution of the patent applications, plaintiff Dana amended the claims by the addition of the term "substantially uniform wall thickness" in the diameter reducing portion. There is no textual description or discussion of

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[1] At oral argument, the parties agreed to the interpretation of a fourth term, "homogeneous." July 18, 2002 hrg. trans. at pp. 5 & 43.

this claim element in the specification of the patents. The only reference pointed to by Dana is the drawings, which show the wall thickness designated by parallel lines, *i.e.*, equal thickness throughout. This would be the common meaning of the term. Since no other meaning is specifically given or pointed to in the specification, the common meaning should be used.

Likewise, in the Petition to Make Special for the '093 patent, Dana characterized the prior art where a tube is swaged on a mandrel to control the inner diameter as having substantially uniform wall thickness. See *Gentry Gallery, Inc. v. Berkline Corp.*, 134 F.3d 1473, 1477 (Fed. Cir. 1998). This is contrasted to an uncontrolled inner diameter produced by normal swaging, which was a non-uniform wall thickness. This limitation was subsequently added to the claims to overcome prior art rejections based on normally waged shafts.

Therefore, the court interprets the phrase "substantially uniform wall thickness" as used in the patents as meaning a wall thickness that does not vary more than the wall variation in the tube wall before swaging.

The claim terms also have the limitation "diameter reducing portion." This limitation generally pertains to the portion of the tube or yoke that transitions from a large diameter to a small diameter. The patents specifically identify the diameter reducing portion. The '093 patent identifies the diameter reducing portion by reference numeral 21 in Figure 2. The diameter reducing portion for the '042 patent is shown in Figure 2 and identified by reference numeral 44. These reference numerals specifically refer to only the transition area, the area where the diameter is changing. This would be the common definition of the term. Therefore, the court interprets the phrase "diameter

reducing portion" to refer only to the transition area where the diameter is changing and not the constant diameter sections both before and after transition portions.

Certain claims have limitations referring to the diameter of the tube, such as "about five inches." See, *e.g.*, Claims 9 and 19 of the '042 patent and Claim 6 of the '093 patent. The use of the word " about" allows for some imprecision. Looking to the specification, one can find the discussion of the importance of the different diameters. In a specific embodiment of the drive line assembly 15, the driveshaft and the tube seat are about 5 inches in diameter, and the lug structure is about 4 inches in diameter. This is expected to be sufficient to enable the use of an unreinforced aluminum alloy driveshaft tube while still providing access for tooling during fabrication of the universal joint 18. '042 patent, column 4, lines 16-22.

Thus, the patent talks about larger diameter imparting sufficient strength to the tube with the narrower diameter allowing access for the powered tooling to the universal joint. The measurements are in terms of about a single significant digit, *i.e.*, a whole number of inches. Neither the specification nor the claim uses any further significant digits such as "about 5.0 inches" or "about 5.00 inches." It simply gives what is known as one significant digit, "about 5 inches." One of ordinary skill in the art would interpret that claim limitation as requiring rounding of any measurement to one significant digit according to standard rules for rounding.

SO ORDERED.

John Corbett O'Meara
United States District Judge

March 3, 2003

APPENDIX D

United States Patent [19] [11] **Patent Number: 5,643,093**

Breese [45] **Date of Patent: *Jul. 1, 1997**

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[54] **ALUMINUM DRIVESHAFT HAVING REDUCED DIAMETER END PORTION**

[75] Inventor: **Douglas E. Breese**, Northwood, Ohio

[73] Assignee: **Dana Corporation**, Toledo, Ohio

[*] Notice: The term of this patent shall not extend beyond the expiration date of Pat. No. 5,637,042.

[21] Application No.: **545,481**

[22] Filed: **Oct. 19, 1995**

[51] **Int. Cl.**[6] **F16C 3/02**

[52] **U.S. Cl.** **464/183;** 464/134

[58] **Field of Search** 464/179, 182, 464/183, 172, 128, 130, 135, 175, 181; 403/309, 298

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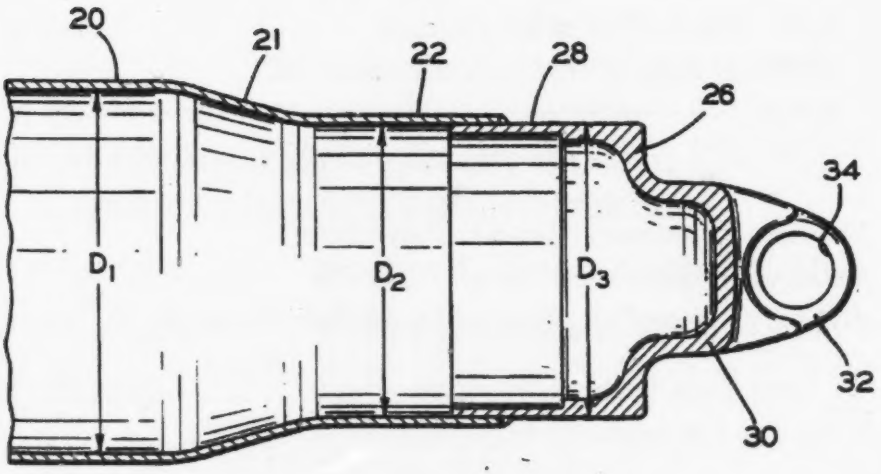
Primary Examiner—Daniel P. Stodola
Assistant Examiner—Eileen A. Dunn
Attorney, Agent, or Firm—MacMillan, Sobanski & Todd

[57] **ABSTRACT**

A driveshaft includes a center portion having a larger diameter, an end portion having a reduced diameter, and a diameter reducing portion positioned between the center and end portions. The reduced diameter end portion of the driveshaft is secured to a reduced diameter tube yoke. This facilitates the introduction of tooling during assembly of a universal joint. The driveshaft is formed by a method which involves first heat treating the driveshaft to a relatively soft temper, then swaging the end portion of the driveshaft, and then heat treating the driveshaft to a relatively hard temper. In more detail, a driveshaft is provided having a predetermined first diameter, the driveshaft being heat treated to achieve a relatively soft temper so as to possess a desired elongation factor. This allows the end

portion of the driveshaft to be swaged to reduce the diameter thereof to a second predetermined diameter. After swaging, the driveshaft is heat treated again to achieve a relatively hard temper to meet the strength requirements for use.

7 Claims, 2 Drawing Sheets



U.S. Patent Jul. 1, 1997 Sheet 1 of 2 5,643,093

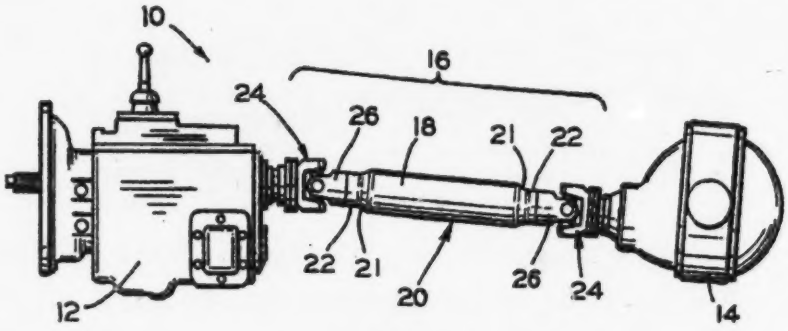


FIG. 1

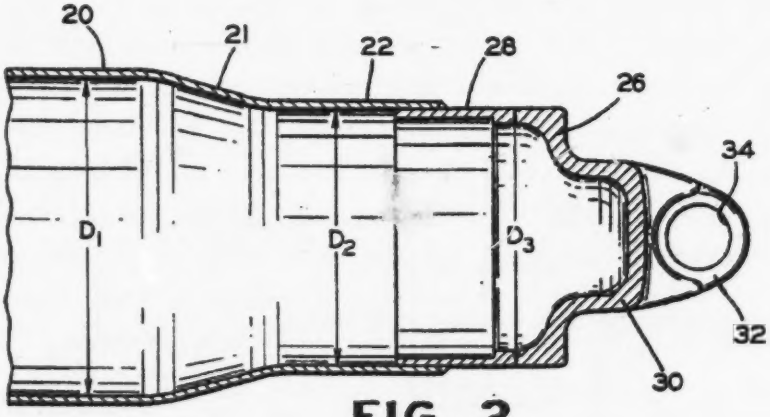


FIG. 2

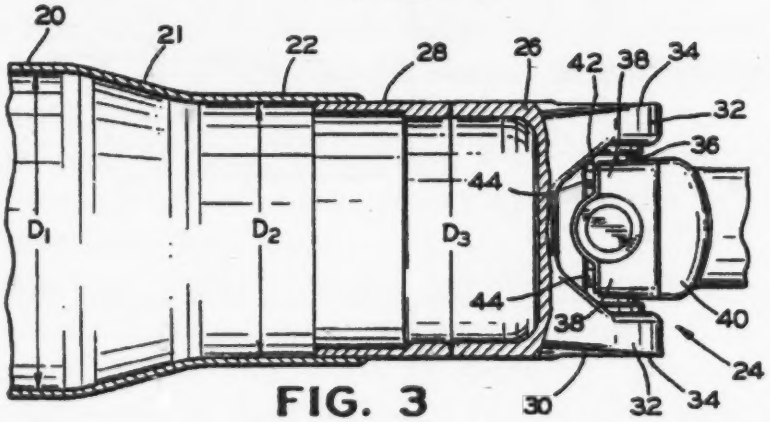


FIG. 3

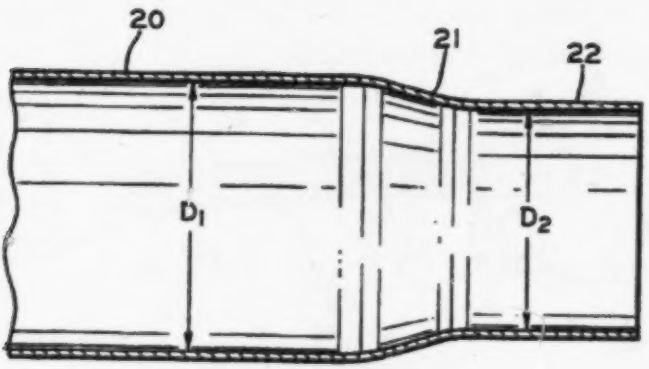


FIG. 4

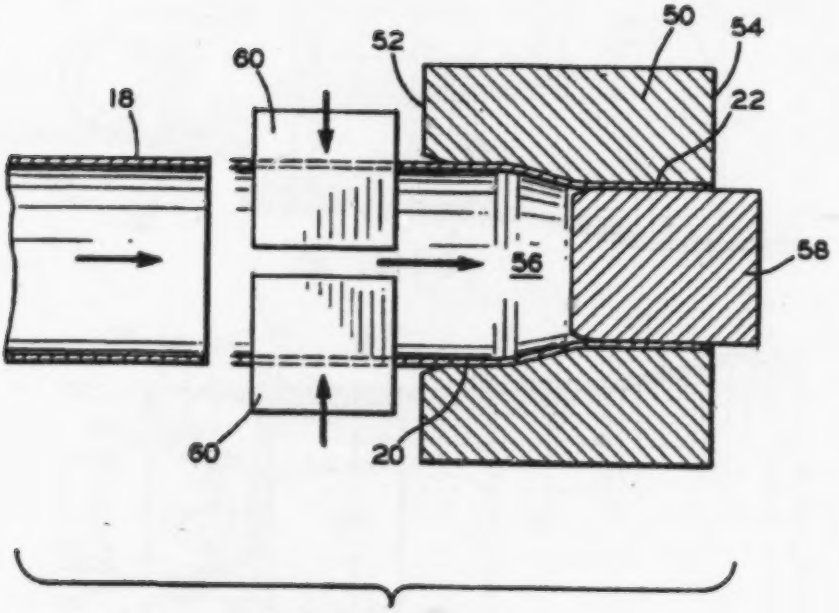


FIG. 5

[1]

ALUMINUM DRIVESHAFT HAVING REDUCED DIAMETER END PORTION

BACKGROUND OF THE INVENTION

This invention relates in general to drive train assemblies for transferring rotational power in vehicles. In particular, this invention relates to an improved structure for an aluminum driveshaft tube for transmitting rotational power from an engine to an axle assembly in a vehicle.

In most land vehicles in use today, a drive train assembly is provided for transmitting rotational power from an output shaft of an engine/transmission assembly to an input shaft of an axle assembly so as to rotatably drive the wheels of the vehicle. To accomplish this, a typical vehicular drive train assembly includes a hollow cylindrical driveshaft tube. A first universal joint is connected between the output shaft of the engine/transmission assembly and the driveshaft tube, while a second universal joint is connected between the driveshaft tube and the input shaft of the axle assembly. The universal joints provide a rotational driving connection from the output shaft of the engine/transmission assembly through the driveshaft tube to the input shaft of the axle assembly, while accommodating a limited amount of misalignment between the rotational axes of these three shafts.

It is known that when any mechanical body is rotated about an axis, a natural resonant frequency is defined thereby. This natural resonant frequency is an inherent characteristic of the mechanical body and is based upon

many factors, including its composition, size, and shape. When the mechanical body is rotated at a speed which is at or near its natural resonant frequency, a relatively large amount of vibration can occur. In the context of a vehicular driveshaft tube, the natural resonant frequency is often referred to as the "critical speed" thereof. Thus, when a driveshaft tube is rotated at or near its critical speed, it can begin to vibrate excessively. Such vibration can, at a minimum, generate undesirable noise in the vehicle during operation. More seriously, this vibration can cause excessive stresses and rapid failure of not only the driveshaft tube, but the other components of the drive train assembly connected thereto. Accordingly, an important consideration in the design and manufacture of driveshaft tubes and other drive train assembly structures is that they not be operated at or near their critical speeds in normal operation.

Thus, the critical speed for a driveshaft tube is a function of, among other things, the nature of the material used to form the driveshaft tube. Generally speaking, the lighter the material used to form the driveshaft, the lower the critical speed. Traditionally, vehicular driveshaft tubes have been formed from steel alloys. Steel alloys have been found to be acceptable materials not only because they possesses sufficient strength to transmit the rotational loads which are normally encountered during use, but also because they are relatively heavy and stiff materials. As a result, the critical speed of steel alloy driveshaft tubes is usually sufficiently high that it is not encountered during normal operation of the vehicle. Unfortunately, because they are relatively heavy materials, steel alloys contribute an undesirable amount to the overall weight of the vehicle. To address this, driveshaft tubes have more recently been

formed from lighter weight alternative materials, such as aluminum alloys. Aluminum alloys have been found to be desirable for use in vehicular driveshaft tubes because they are much lighter than steel alloys, yet possess sufficient strength to transmit the rotational loads therethrough. Unfortunately, for this same rea[2]son of lighter weight, the critical speed of an aluminum alloy driveshaft tube is usually much lower than the critical speed of a comparably sized steel alloy driveshaft tube. The critical speeds of typical aluminum alloy driveshaft tubes have been found to be undesirably close to the normal operating speeds of the vehicle than comparable steel alloy driveshaft tubes.

As mentioned above, the critical speed for a driveshaft tube is also a function of the size and shape of the driveshaft tube. Generally speaking, the longer the driveshaft tube is in length and the smaller it is in diameter, the lower the critical speed. The use of aluminum alloys has allowed the replacement of traditional two-piece steel alloy driveshaft tubes with newer one-piece aluminum alloy driveshaft tubes. The newer one-piece driveshaft tubes are preferable to the traditional two-piece steel alloy driveshaft tubes because fewer parts are required. However, because they are longer in length, one-piece aluminum alloy driveshaft tubes have a lower critical speed than a comparably sized two-piece steel alloy driveshaft tubes, undesirably close to the normal operating speeds of the vehicle than comparable steel alloy driveshaft tubes.

Attempts have been made to alter the critical speed of one-piece aluminum alloy driveshaft tubes to facilitate their use in vehicles. For example, it is known that the critical speed of an aluminum alloy driveshaft can be increased by covering it with a coating of a high strength material, such as a resin matrix reinforced with graphite

fibers. Though effective, the use of such a covering undesirably increases manufacturing costs. It would be advantageous, therefore, to provide an improved structure for a driveshaft tube which would enable the use of lighter weight aluminum alloys, yet would not require the use of relative expensive reinforcing coatings to raise the critical speed thereof above the normal operating speed of the vehicle.

SUMMARY OF THE INVENTION

This invention relates to an improved structure for a vehicular driveshaft tube which enables the use of lighter weight aluminum alloys, yet which has a critical speed which is sufficiently high as to not be encountered during normal use of the vehicle. A new driveshaft has now been developed which permits the use of a larger diameter driveshaft while still allowing the requisite access for the tooling needed to assemble the universal joints. By using a larger diameter driveshaft, the driveshaft can be formed from an aluminum alloy and yet not require an expensive reinforcing coating. The increase in the driveshaft diameter will increase the critical speed to a commercially acceptable level. In order to enable the use of a larger diameter driveshaft while still allowing the requisite access for the tooling to put together the universal joints, there is a diameter reduction which provides a conversion from the larger diameter driveshaft to a reduced diameter tube yoke. This invention provides this diameter reduction by forming a driveshaft with a center portion having a larger diameter and an end portion having a reduced diameter. A diameter reducing portion of the driveshaft is positioned between the center portion and the end portion. The

reduced diameter end portion of the driveshaft is secured to the reduced diameter tube yoke. This facilitates the introduction of tooling to the lug bolts during assembly of the universal joints. The driveshaft of the invention is formed by a method which involves first heat treating the driveshaft to a relatively soft temper, then swaging the end portion of the driveshaft to reduce the diameter thereof, and then heat treating the driveshaft again to a relatively hard temper. In more detail, a driveshaft is provided having a predetermined first diameter, the drive[3]shaft being heat treated to achieve a relatively soft temper so as to possess a desired elongation factor. This allows the end portion of the driveshaft to be swaged to reduce the diameter thereof to a second predetermined diameter. After the swaging operation, the driveshaft is heat treated again (referred to as "aging") to achieve a relatively hard temper to meet the strength requirements for use.

Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiments, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevational view schematically illustrating a vehicle drive train including an improved driveshaft in accordance with this invention.

FIG. **2** is a side plan view, partially in cross section, of one end of a driveshaft in accordance with this invention connected to a tube yoke.

FIG. **3** is a top plan view (rotated 90 degrees from FIGS. **1** and **2**), partially in cross section of one end of a drive-

shaft in accordance with this invention connected to a tube yoke, and the tube yoke connected to a universal joint.

FIG. **4** is a cross-sectional view illustrating one end of a driveshaft in accordance with this invention.

FIG. **5** is a schematic cross-sectional view of a push pointing operation for swaging the end portion of the driveshaft.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, there is illustrated in FIG. **1** a vehicle drive train assembly, indicated generally at **10**. The drive train assembly **10** includes a transmission **12** having an output shaft (not shown) which is connected to an input shaft (not shown) of an axle assembly **14** through driveshaft assembly **16**. The transmission **12** is rotatably driven by an engine (not shown) which generates rotational power in a conventional manner. The driveshaft assembly **16** includes a cylindrical driveshaft tube **18** having a center portion **20** and opposing end portions **22**. As will be explained in greater detail below, the center portion **20** of the driveshaft tube **18** is formed having a larger outer diameter than either of the end portions **22**. Thus, a transition region **21** is defined between the larger diameter center portion **20** of the driveshaft **18** and each of the smaller diameter end portions **22** thereof.

The output shaft of the transmission **12** and the input shaft of the axle assembly **14** are typically not co-axially aligned. To accommodate this, a universal joint, indicated generally at **24**, is provided at each of the end portions **22** of the driveshaft tube **18** to rotatably connect the drive-

shaft tube **18** to the output shaft of the transmission **12** and the input shaft of the axle assembly **14**. FIG. **3** illustrates the universal joint **24** provided between the end portion **22** of the driveshaft tube **18** and the input shaft of the axle assembly **14**. As shown therein, the universal joint **24** includes a tube yoke **26** which is secured to the end portion **22** of the driveshaft tube **18**. The tube yoke **26** is formed having a tube seat **28** at one end and the lug structure **30** at the other end. The tube seat **28** is adapted to be secured to the end portion **22** of the driveshaft **18** to enable torque to be transmitted between the driveshaft tube **18** and the tube yoke **26**. The tube seat **28** defines an outer diameter D_3 which will be discussed below.

The illustrated tube yoke **26** is a full round yoke, wherein the lug structure **30** includes a pair of opposed lug ears **32** [**4**] having co-axially aligned cross holes **34** formed therethrough. The cross holes **34** are provided to receive two opposed beating caps mounted on respective trunnions of a cross **36** (see FIG. **3**) in a well known manner. The other two trunnions of the cross **36** are connected to lug ears **38** provided on an end yoke **40** connected to the input shaft of the axle assembly **14**. The illustrated end yoke **40** is a half round yoke, including a pair of straps **42** (only one is illustrated) which surround the beating caps mounted on the end of the respective trunnions to retain them therewith. The straps **42** are secured to the lug ears **38** by bolts **44** which can be threaded into the lug ears **38**. The universal joint **24** provided between the output shaft of the transmission **12** and the end portion **22** of the driveshaft tube **18** has a similar structure.

The structure of the driveshaft tube **18** of this invention is illustrated in more detail in FIG. **4**. As shown therein, the center portion **20** of the driveshaft tube **18** defines an inner

diameter D_1 which is larger than an inner diameter D_2 defined by the end portion **22** of the driveshaft tube **18**. As discussed above, the transition region **21** extends between the larger center portion **20** of the driveshaft tube **18** and the end portion **22**. Preferably, the inner diameter defined by the transition region **21** reduces in a smooth curve from the larger diameter center portion **20** to the smaller diameter end portion **22** for ease of manufacture and more uniform stress distribution. Referring back to FIGS. **2** and **3**, it can be seen that the inner diameter D_2 of the end portion **22** of the driveshaft **18** is approximately the same as the outer diameter D_3 of the tube seat **28** provided on the tube yoke **26**. Thus, the outer diameter D_3 of the tube seat **28** is smaller than the inner diameter D_1 of the center portion **20** of the driveshaft tube **18**. Either one end portion **22** or both end portions **22** of the driveshaft **18** can be formed in this manner.

Preferably, the inner diameter D_2 of the end portion **22** of the driveshaft tube **18** is within the range of from about 73% to about 85% of the inner diameter D_1 of the center portion **20** of the driveshaft tube **18**. Most preferably, the inner diameter D_2 of the end portion **22** of the driveshaft tube **18** is within the range of from about 78% to about 85% of the inner diameter D_1 of the center portion **20** of the driveshaft tube **18**. In a specific preferred embodiment of the invention, the center portion **20** of the driveshaft tube **18** has an inner diameter D_1 of about five inches, while the end portion **22** of the driveshaft tube **18** has an inside diameter D_2 of about four inches. These dimensions provide an excellent unreinforced aluminum alloy driveshaft which facilitates access for tooling during assembly of the universal joint **24**.

The method of forming the driveshaft tube **18** of this invention will now be explained. Initially, a driveshaft tube blank is provided having a predetermined first diameter. The driveshaft tube blank is initially heat treated to achieve a relatively soft temper and, therefore, a desired elongation factor. The driveshaft tube blank can be formed from any suitable material, but is preferably formed from an aluminum alloy metal. A preferred process for forming the driveshaft includes both extrusion and drawing. In this process, a solid aluminum alloy cylinder having about the desired length and diameter is placed into an extrusion press. A rod is forced through the middle of the solid aluminum alloy cylinder to form the internal diameter of the driveshaft tube blank. The aluminum alloy cylinder is then forced around an inner mandrel and through an extrusion die to form the extruded driveshaft tube blank. At this point, the shape of the driveshaft is close to the desired final shape. The extruded driveshaft is then subjected to a drawing operation to refine **[5]** the dimensions and properties thereof. The process provides a hollow aluminum alloy driveshaft tube blank of the desired inside diameter, thickness, and amount of cold work. The inside diameter of the driveshaft tube blank at this point is equal to the inside diameter D_1 discussed above.

The above-mentioned heat treating operation can be performed during formation of the driveshaft tube blank, for example between the extrusion and drawing steps, or it can be performed after the driveshaft tube blank has been formed. The heat treated driveshaft tube blank will possess a desired elongation factor so that the end portions **20** can be reduced or swaged into a desired shape. Preferably, the elongation factor of the driveshaft tube blank after this

heat treating operation is between about 15% and about 22%, and more preferably about 20%.

Taking advantage of this higher elongation factor for the material, the end portion **22** of the driveshaft tube blank is then swaged to reduce the diameter thereof to a second predetermined inside diameter. This reduced inside diameter is equal to the inside diameter D_2 discussed above. Any of the several well-known known methods for swaging metal can be used to form the end portions **20** of the driveshaft tube **18**. A preferred method of swaging the end portion of the driveshaft is a push pointing operation, which is illustrated in FIG. **5**. In this method, the driveshaft tube blank is pushed axially into a reducing push point die **50**. The push point die **50** includes a front surface **52** which faces toward the driveshaft tube blank and a rear surface **54** which faces away from the driveshaft tube blank. A cylindrical opening **56** is formed through the push point die **50** having a larger diameter near the front surface **52** and a smaller diameter near the back surface **54**. A mandrel **58** is positioned inside the opening **56** in the smaller diameter portion thereof. The mandrel **58** has an outer diameter which is equal to the desired inside diameter D_2 of the end portion **22** of the finished driveshaft tube **18**. Grippers **60** are provided which engage the outer surface of the driveshaft tube blank and force it into the opening **56** of the push point die **50**. As the driveshaft tube blank is pushed axially into the opening **56**, the leading end thereof is reduced in diameter by engagement with the die **50** and the mandrel **58** to form the end portion **22** of the driveshaft tube **18**. The remaining portion of the driveshaft tube blank retains the larger diameter size to form the center portion **20** of the driveshaft tube **18**. Alternatively, the end portion **22** can be formed by rotary swaging. Rotary swaging

employs a die which rotates while it alternately rapidly collapses and expands in a radial direction, much like a hammer. The end portion of the driveshaft is pushed into the die, and the die hammers the end portion of the driveshaft down into the desired reduced diameter.

After this swaging operation is performed, the driveshaft tube **18** is again heat treated by subjecting it to an elevated temperature for a predetermined time. This heat treatment is performed to achieve a relatively hard temper to meet the strength requirements for use. This produces a driveshaft **18** in accordance with the present invention.

The end portion **22** of the driveshaft **18** is secured to the tube yoke **26** as shown in FIG. **2**. Specifically, the tube seat **28** of the tube yoke **26** is inserted within the end portion **22** of the driveshaft **18**. The inside diameter D_2 of the end portion **22** of the driveshaft **18** is preferably sized to be slightly smaller than the outside diameter D_3 of the tube seat **[6] 28**. Preferably, the inside diameter D_2 of the end portion **22** of the driveshaft **18** is within the range of from about 98% to about 99.9% of the outside diameter D_3 of the tube seat **28** prior to the insertion of the tube seat **26** into the driveshaft tube **18**. After such insertion, the tube seat **26** is slightly deformed since the outside diameter D_3 of the tube seat **28** equals the inside diameter D_2 of the end portion **22** of the driveshaft **18**. By making the tube seat diameter D_3 slightly larger than inside diameter D_2 prior to insertion of the tube seat **26** into the driveshaft tube **18**, the two parts will have an interference fit or press fit which provides some torque transmitting capacity. The torque transmitting capacity of the connection between the driveshaft **18** and the tube yoke **26** is increased by providing a weld.

While the first and second predetermined diameters have been discussed hereinabove as inside diameters of the

driveshaft, they could also be outside diameters if the tube yoke was secured outside the end portion of the driveshaft instead of fitting inside the end portion of the driveshaft.

It will be evident from the foregoing that various other modifications can be made to this invention. Such, however, are considered as being within the scope of the invention.

What is claimed is:

1. A drive line assembly comprising:

a driveshaft robe formed from a metallic material and including a homogeneous diameter reducing portion having a substantially uniform wall thickness, said diameter reducing portion including an axially extending cylindrical first end extending from said driveshaft tube, said diameter reducing portion further including an axially extending cylindrical second end, said axially extending cylindrical first end of said diameter reducing portion defining a first diameter, said axially extending cylindrical second end of said diameter reducing portion defining a second diameter, said first diameter being larger than said second diameter; and

a tube yoke formed from a metallic material and including an axially extending cylindrical end portion having a substantially uniform wall thickness which is co-axial with and permanently fixed to said axially extending cylindrical second end portion of said diameter reducing portion of said driveshaft tube, said tube yoke further including a pair of opposed lug ears extending from said end portion and having respective orifices formed therethrough.

2. The drive line assembly defined in claim **1** wherein said driveshaft tube is formed from an aluminum alloy.

3. The drive line assembly defined in claim **1** wherein said tube yoke is formed from an aluminum alloy.

4. The drive line assembly defined in claim **1** wherein said driveshaft tube and said tube yoke are both formed from an aluminum alloy.

5. The drive line assembly defined in claim **1** wherein said diameter reducing portion of said driveshaft tube is welded to said tube yoke.

6. The drive line assembly defined in claim **1** wherein said first diameter is about five inches and said second diameter is about four inches.

7. The drive line assembly defined in claim **1** further including a universal joint assembly connected with said tube yoke.

* * * * *

UNITED STATES
PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,643,093

DATED : July 1, 1997

INVENTOR(S) : Douglas E. Breese

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Claim 1, Column 6, Line 2,

after "driveshaft", change "robe" to

—tube—.

Signed and Sealed this

Second Day of September, 1997

Attest: /s/ Bruce Lehman

BRUCE LEHMAN

Attesting Officer *Commissioner of Patents and Trademarks*

APPENDIX E

United States Patent [19] [11] **Patent Number: 5,637,042**

Breese [45] **Date of Patent: Jun. 10, 1997**

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[54] **DRIVE LINE ASSEMBLY WITH REDUCING TUBE YOKE**

[75] Inventor: **Douglas E. Breese**, Northwood, Ohio

[73] Assignee: **Dana Corporation**, Toledo, Ohio

[21] Application No.: **407,769**

[22] Filed: **Mar. 21, 1995**

[51] **Int. Cl.**[6] **F16C 3/02**

[52] **U.S. Cl.** **464/183;** 464/134; 464/179

[58] **Field of Search** 464/134, 179, 464/181, 182, 183

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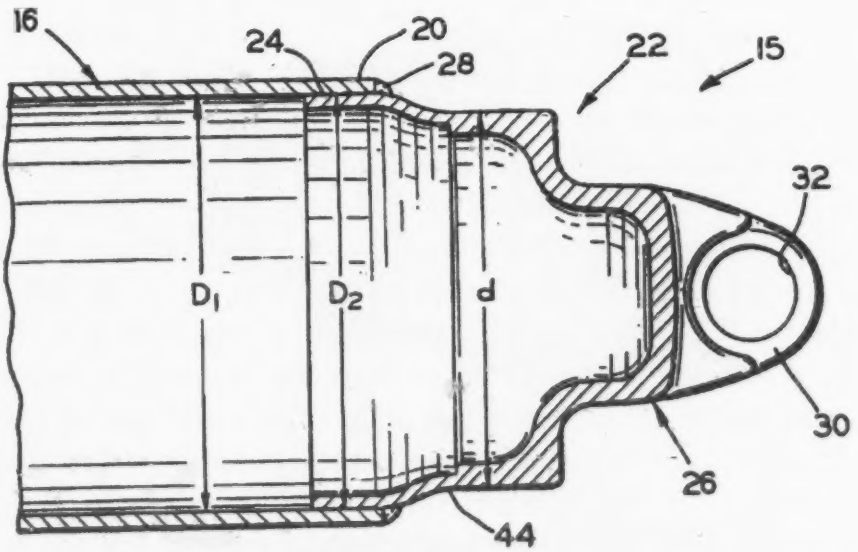
Primary Examiner—Daniel P. Stodola
Assistant Examiner—Eileen A. Dunn
Attorney, Agent, or Firm—MacMillan, Sobanski & Todd

[57] **ABSTRACT**

A drive line assembly includes a cylindrically shaped driveshaft tube and a tube yoke, one end of the driveshaft tube fitting over the tube yoke in an interference fit sufficient to transfer torque between the driveshaft tube and the tube yoke, the tube yoke comprising a tube seat at one end for mating in a torque transferring relationship with the

end of the driveshaft. The other end of the driveshaft tube yoke has a lug structure for transferring torque to other rotatable elements through a universal joint. The tube yoke has a diameter reducing portion intermediate the tube seat and the lug structure so that the lug structure is smaller in diameter than the drive shaft tube and the tube seat to facilitate the introduction of tooling to the lug structure during assembly operations of the universal joint.



19 Claims, 1 Drawing Sheet

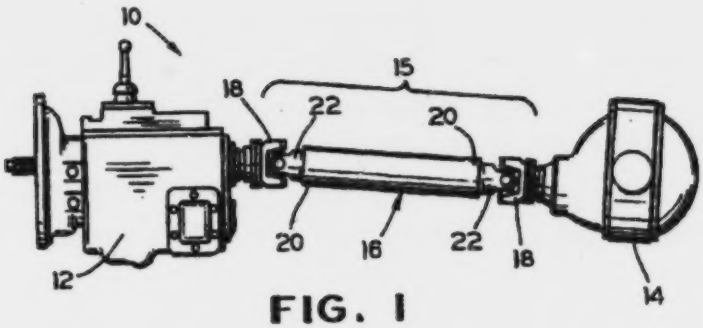


FIG. 1

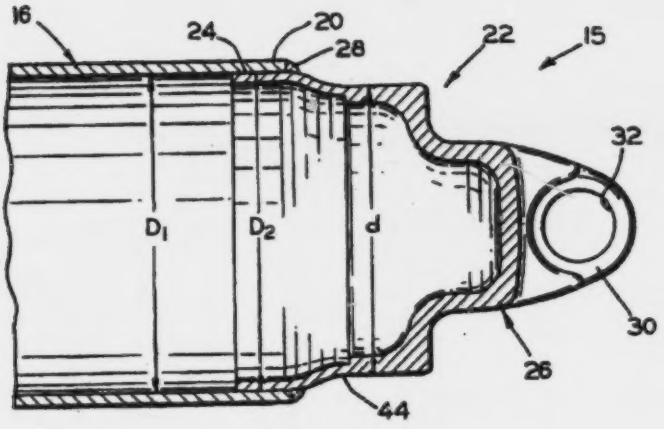


FIG. 2

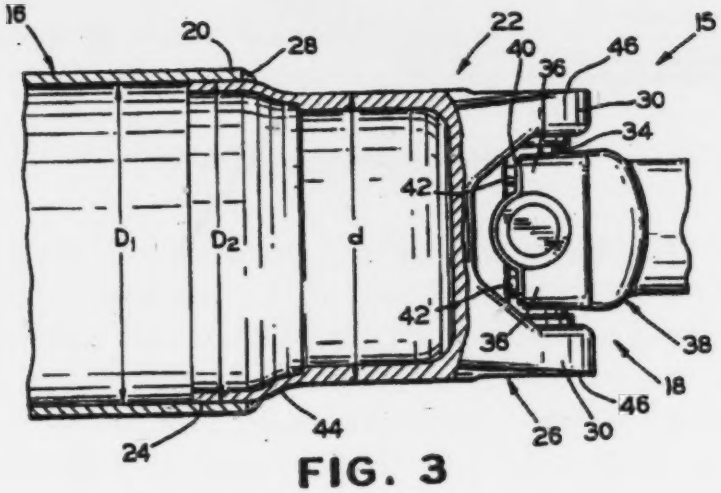


FIG. 3

[1]

DRIVE LINE ASSEMBLY WITH REDUCING TUBE YOKE

BACKGROUND OF THE INVENTION

This invention relates in general to drive line assemblies suitable for transferring power in a vehicle, and in particular to an improved drive line apparatus for transferring torque from a rotating tubular driveshaft to a universal joint assembly.

Metallic torque transmitting shafts and similar components are widely used for many different applications. In particular, metal torque transmitting shafts are frequently used in vehicular drive trains including axle shafts, yoke shafts and the like. In use, these shafts can be subjected to relatively large torque loads imposed on them by the vehicle engine to move the vehicle. It is desirable for these torque-bearing members to be as strong as possible while still being light weight. Typically, driveshaft members are hollow to provided the maximum strength for the weight involved. It is known that driveshafts must be rotated at speeds below their critical speed to avoid resonance which leads to self destruction. The critical speed for any given driveshaft is a function of the density, modulus and geometry of the material in the driveshaft. Generally, the smaller the driveshaft diameter, the lower the critical speed of the driveshaft. Therefore it is desirable for the driveshaft to be at least as large in diameter as a specified minimum size for a particular driveshaft length and composition of material.

Vehicle driveshafts usually are adapted with universal joint assemblies for connection to other rotating drive line elements. The universal joints help accommodate differences in angular alignment between two rotating elements, such as a transmission output shaft and a driveshaft tube. Universal joints further enable a small amount of relative movement between the driveshaft and an adjacent rotating part, such as a transmission output shaft or an axle assembly input shaft. In a typical vehicle driveline assembly the driveshaft tube is connected at each of its ends to a tube yoke which connects to a universal joint assembly. The universal joint assembly usually consists of a journal cross and four bearing assemblies. Typically assembly involves securing the universal joint into place with a bearing strap and a plurality of lug bolts. An important requirement for the assembly of the driveline apparatus is gaining access to various driveline elements for the insertion of tools necessary to complete the assembly. In particular it is important to be able to reach the lug bolts during the assembly of the universal joint. Power tooling is used, and the tooling must be accurately aligned to obtain the proper torque on the lug bolts.

Past attempts to lower the weight of vehicle driveshafts have resulted in replacing traditional two-piece steel driveshafts with lighter weight one-piece aluminum alloy driveshafts. This reduces the driveshaft weight, but, because it is longer, requires a larger diameter driveshaft for the same critical speed. The critical speed of the driveshaft can be increased by coveting the driveshaft with a high modulus coating, such as a resin matrix reinforced with graphite fibers, but this increases the manufacturing cost. It would be advantageous if there could be developed a driveline assembly which would enable the substitution of lighter

weight aluminum alloys for the traditional steel tubes, and yet not require the use of expensive reinforcing coatings. Any solution to the problem would have to include the requisite access for the tooling needed to assemble the universal joints at the ends of the driveline tube.

[2]
SUMMARY OF THE INVENTION

A new drive line assembly has now been developed which permits the use of a larger diameter driveshaft tube while still allowing the requisite access for the tooling to put together the universal joint assembly. By using a larger diameter driveshaft, the driveshaft can be made of an aluminum alloy and yet not require an expensive reinforcing coating. The increase in the driveshaft diameter will increase the critical speed to a commercially acceptable level. In order to enable the use of a higher diameter driveshaft tube while still allowing the requisite access for the tooling to put together the universal joint assembly, there must be a diameter reduction element which provides a conversion from the larger diameter driveshaft tube to the smaller diameter lug structure of the tube yoke.

The drive line assembly includes a driveshaft tube and a tube yoke, with the driveshaft tube having a diameter greater than the general diameter of the lug structure of the tube yoke. The tube yoke has a diameter reducing portion which provides the reduction in diameter necessary to permit access of the tooling.

The driveshaft tube fits over the tube yoke in an interference fit sufficient to transfer torque between the driveshaft tube and the tube yoke. The tube yoke has a tube seat at one end for mating in a torque transferring relationship

with the end of the driveshaft tube. The tube yoke has a lug structure at its other end for transferring torque to other rotatable elements through a universal joint. The lug structure is smaller in diameter than the drive shaft tube and the tube seat. The diameter reducing portion of the tube yoke is positioned intermediate the tube seat and the lug structure to facilitate the introduction of tooling to the lug structure during assembly operations of the universal joint. The lug structure provides the connection point of the universal joint to the tube yoke.

In a preferred embodiment of the invention, the tube seat is a formed element, and is not machined. Also, the tube yoke is preferably a unitary element, being of one piece and not welded, bolted or threaded together. A fillet weld can be used to attach the driveshaft tube to the tube yoke. Both the driveshaft tube and the tube yoke are preferably metallic, and most preferably of an aluminum alloy.

Various objects and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiments, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view in elevation of a drive train incorporating the drive line assembly of the invention.

FIG. **2** is a schematic plan view, partially in cross-section, of a drive shaft and tube yoke in accordance with this invention.

FIG. **3** is a schematic view in elevation, partially in cross section, of the drive line assembly illustrated in FIG. **2**, rotated 90 degrees from the view in FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. **1**, the drive train, indicated generally at **10**, is comprised of transmission **12** connected to axle assembly **14** through drive line assembly **15**. The drive line assembly includes a cylindrically shaped driveshaft or driveshaft tube **16**. The driveshaft can be of any suitable material, but is preferably hollow and metallic, most preferably of a **[3]** lightweight aluminum alloy such as a 6061 alloy. As is typical in vehicle drive trains, the transmission output shaft, not shown, and the axle assembly input shaft, not shown, are not coaxially aligned. Therefore, universal joints **18** are positioned at each end **20** of the driveshaft to rotatably connect the driveshaft to the transmission output and the axle assembly input. The connection between the ends **20** of the driveshaft and the universal joints is accomplished by tube yokes **22**. The drive train apparatus described thus far is generally conventional, and is well known in the industry.

As shown more clearly in FIG. **2**, the tube yoke **22** is comprised of the tube seat **24** at one end, and the lug structure **26** at the other end. The tube yoke can be made of any suitable material, and is preferably metallic, being of an aluminum alloy. The tube yoke can be made by casting or by forging, and is preferably a formed element which is subjected to a draw and iron stamping process to set the final dimensions of the tube seat outside diameter D_2, thereby eliminating the necessity of machining the tube seat. The term "formed element" means that the element is pushed or shaped into its final form without the loss of any material, rather than being machined, turned or milled, which would involve the removal of material to obtain the

final form. Since a formed element does not require a machining process, the formed element is less costly to manufacture. Also, the tube yoke is preferably a unitary element, which means it is of one piece, and is not welded, threaded or bolted together.

The draw and iron process is similar to a coining process and involves pressing or punching a workpiece into a draw and iron die. Prior to the draw and iron process, the workpiece is already generally formed into the net shape or final shape of the final part, either by a casting or a forging process. The draw and iron die is made of die steel. Forcing the relatively soft aluminum alloy with a single die stroke into the die, forms and smoothes the forged or cast surface of the tube seat into a part having the desired dimensions, generally within a tolerance about ±0.002 inches. The draw and iron process is well known to those skilled in the art.

The tube seat is adapted to mate or fit with the end **20** of the driveshaft tube **16** to enable torque to be transmitted between the driveshaft tube and the tube seat. The torque transmitting capacity of the connection between the driveshaft tube and the tube yoke is increased by providing a weld, such as fillet weld **28**. Although a fillet weld is preferred, other welds could be used.

The lug structure is comprised of lug ears **30** adapted with cross orifices **32** which receive the universal joint bearing assemblies, not shown in FIG. **2**, but shown as universal joint journal cross **34** in FIG. **3**. The cross is connected to the end yoke lug ears **36** of the end yoke **38** to form the complete universal joint **18**. The end yoke is connected to other rotatable drive train elements. The end yoke lug ears **36** can be held in place around the journal cross bearings by any retaining device, such as by bearing

strap **40**, as shown in FIG. **3**. The bearing strap is secured to the end yoke lug ears by lug bolts **42**, which can be threaded into the end yoke lug ears. Access must be provided to the lug bolts during assembly of the drive line assembly in order to secure the bearing strap into place. The lug structure **26** transmits torque through the universal joint, to or from other rotatable drive line elements, such as the transmission **12** and the axle assembly **14**.

It can be seen that the generalized diameter d of the lug structure **26** is less than the outside diameter D_2 of the tube seat **24**. Positioned intermediate the tube seat and the lug [4] structure is the tube yoke diameter reducing portion **44** which provides for a change in diameter of the tube yoke to accommodate both the inside diameter D_1 of the enlarged driveshaft tube **16** and the smaller diameter d of the lug structure. It is to be understood that the lug structure is not usually perfectly cylindrical, and therefore does not have a definitive diameter. However, the lug structure usually has oppositely spaced, generally planar or arcuate faces, such as lug faces **46**, shown more clearly in FIG. **3**, which can be used to provide a generalized diameter of the lug structure. In the preferred embodiment of the invention, the general diameter d of the lug structure is within the range of from about 0.60 to about 0.95 of the tube seat diameter D_2. Most preferably, the general diameter d of the lug structure is within the range of from about 0.80 to about 0.93 of the tube seat diameter D_2. In a specific embodiment of the drive line assembly **15**, the driveshaft and the tube seat are about 5 inches in diameter, and the lug structure is about 4 inches in diameter. This is expected to be sufficient to enable the use of an unreinforced aluminum alloy driveshaft tube while still providing access for tooling during fabrication of the universal joint **18**.

The diameter reducing portion **44** is preferably designed with a smooth curve for ease of manufacture, but could also be formed with a step-like diameter reduction. It is important that the diameter reducing portion be positioned far enough away from the lug bolts that the tooling for the lug bolts, such as power wrenches, can be inserted in place. Preferably, the diameter reducing portion is positioned at least $2^3/_4$ inches from the lug bolts.

During the fabrication of the drive line assembly **15**, the tube seat **24** is inserted into the end **20** of the driveshaft tube **16**. The inside diameter D_1 of the driveshaft is preferably sized to be slightly smaller than the outside diameter D_2 of the tube seat. Preferably, the driveshaft tube inside diameter D_1 is within the range of from about 0.980 to about 0.999 of the tube seat diameter D_2 prior to the insertion of the tube seat into the driveshaft tube. After the insertion of the tube seat into the driveshaft, the tube seat becomes slightly deformed since at that point the tube seat diameter D_2 equals the driveshaft tube inside diameter D_1. By making the tube seat diameter D_2 slightly larger than the driveshaft tube inside diameter D_1 prior to insertion of the tube seat into the driveshaft, the two parts will have an interference fit or press fit, which provides some torque transmitting capacity.

In operation, a drive line assembly **15** includes a relatively large driveshaft tube **16** and a tube yoke **22** fitting within the end **20** of the tube. The tube yoke has a lug structure **26** for connection through a universal joint **18** to other rotating parts of the drive train. The lug structure is relatively smaller in diameter than the driveshaft tube, and the tube yoke is adapted with a diameter reducing portion **44** which provides a transition between the relatively large diameter D_1 of the driveshaft tube and the relatively small

diameter d of the lug structure. This allows the insertion of the tooling necessary for securing the lug bolts **42** within the universal joint assembly **18**.

It will be evident from the foregoing that various modifications can be made to this invention. Such, however are considered as being within the scope of the invention.

What is claimed is:

1. A drive line assembly comprising:

a driveshaft tube formed from a metallic material and having a substantially uniform wall thickness, said driveshaft tube terminating in an axially extending cylindrical end portion;

[5]

a diameter reducing portion formed from a metallic material and having a substantially uniform wall thickness, said diameter reducing portion including an axially extending cylindrical first end which is co-axial with and permanently fixed to said axially extending cylindrical end portion of said driveshaft tube, said diameter reducing portion further including an axially extending cylindrical second end, said axially extending cylindrical first end of said diameter reducing portion defining a first diameter, said axially extending cylindrical second end of said diameter reducing portion defining a second diameter, said first diameter being larger than said second diameter; and

a tube yoke formed from a metallic material and including a pair of opposed lug ears having respective orifices formed therethrough, said tube yoke including an axially extending cylindrical end portion which is co-axial with and permanently fixed to said axially

extending cylindrical second end of said diameter reducing portion for axial and rotational movement therewith.

2. The drive line assembly defined in claim **1** wherein said driveshaft tube is formed from an aluminum alloy.

3. The drive line assembly defined in claim **1** wherein said diameter reducing portion is formed from an aluminum alloy.

4. The drive line assembly defined in claim **1** wherein said tube yoke is formed from an aluminum alloy.

5. The drive line assembly defined in claim **1** wherein said driveshaft tube, said diameter reducing portion, and said tube yoke are all formed from an aluminum alloy.

6. The drive line assembly defined in claim **1** wherein said driveshaft tube is welded to said diameter reducing portion.

7. The drive line assembly defined in claim **1** wherein said diameter reducing portion is formed homogeneously with said tube yoke.

8. The drive line assembly defined in claim **1** wherein said driveshaft tube is welded to said diameter reducing portion and said diameter reducing portion is formed homogeneously with said tube yoke.

9. The drive line assembly defined in claim **1** wherein said first diameter is about five inches and said second diameter is about four inches.

10. The drive line assembly defined in claim **1** further including a universal joint assembly connected with said tube yoke.

[6]

11. A drive line assembly comprising:

a driveshaft tube formed from a metallic material and having a substantially uniform wall thickness, said driveshaft tube terminating in an axially extending end portion; and

a tube yoke formed from a metallic material and including a homogenous diameter reducing portion having a substantially uniform wall thickness, said diameter reducing portion including an axially extending first end which is co-axial with and permanently fixed to said axially extending end portion of said driveshaft tube, said diameter reducing portion further including an axially extending second end, said axially extending first end of said diameter reducing portion defining a first diameter, said axially extending second end of said diameter reducing portion defining a second diameter, said first diameter being larger than said second diameter, said tube yoke further including a pair of opposed lug ears extending from said second end of said diameter reducing portion and having respective orifices formed therethrough.

12. The drive line assembly defined in claim **11** further including a universal joint assembly connected with said tube yoke.

13. The drive line assembly defined in claim **11** wherein said axially extending end portion of said driveshaft tube and said axially extending first end of said diameter reducing portion are cylindrical.

14. The drive line assembly defined in claim **11** wherein said axially extending first end of said diameter reducing

portion and said axially extending second end of said diameter reducing portion are cylindrical.

15. The drive line assembly defined in claim **11** wherein said driveshaft tube is formed from an aluminum alloy.

16. The drive line assembly defined in claim **11** wherein said tube yoke is formed from an aluminum alloy.

17. The drive line assembly defined in claim **11** wherein said driveshaft tube and said tube yoke are both formed from an aluminum alloy.

18. The drive line assembly defined in claim **11** wherein said driveshaft tube is welded to said first end of said diameter reducing portion of said tube yoke.

19. The drive line assembly defined in claim **11** wherein said first diameter is about five inches and said second diameter is about four inches.

* * * * *